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The Institute of Vitreous Enamellers
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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The Registered Office and Laboratories of the B.C.I.R.A. are :—
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Telephone : Colmore 4274-4275 Telegrams : CIRA
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Foundry Technical Institute, Meek's Road, Falkirk
Telephone : 332

Contents

	PAGE
The Progress of Alloying Cast Iron	397
Correspondence	398
Catalogues Received	398
Random Shots	398
Cupola Control	399
Moulding Cast-Iron Cooking-Pans	402
Permanent Magnets	402
Cracking of Ingot Moulds	403
Foundry Sands	406
Shearing of Malleable Iron Gates	408
Training the Young Foundryman	409
Iron and Steel Production	410
Production of Bronze Pressure Castings	410
Book Review	410
The Week's News in Brief	412
Trade Talk	412
Personal	412
New Companies	412
Company Reports	412
Contracts Open	412
Raw Material Markets	414
Pouring-Ladle Influence on Brass	414

The Progress of Alloying Cast Iron

In 1935, the American Foundrymen's Association did an outstanding service to the foundry industry of the world by the publication of their "Cast Metals Handbook," because they thereby rendered easily available to the buyer of castings the physical and mechanical properties of the unwrought alloys. This praiseworthy effort has now been followed up by "Alloy Cast Irons,"* which, unlike its forerunner, is primarily meant for the foundry executive. In America, as in the United Kingdom, there are several information bureaux whose object it is to procure and disseminate straightforward technical data as to the applicability of a metal to various industrial uses. Thus, in 1934, it was deemed wise to form a committee having representation from the metal producers, the manufacturers and users of alloy cast iron, and the appropriate technical societies, and charged with the duty of publishing a book containing the data so far available. They have done their work remarkably well, and they have been well supported by the officials of the Association.

The following definition is given of "plain" cast iron :—"Cast iron is essentially an alloy of iron and carbon in which the carbon is present in excess of the amount which can be retained in solid solution at the eutectic temperature." This is followed by a definition of alloy cast iron which will receive general approbation as to both conception and wording. The first chapter is admittedly an assembly of generalities and is no worse for that, because a study of what follows indicates the vastness of the field still to be covered before anything like finality is reached. The next chapter enters into somewhat more detail by taking sixteen elements alphabetically and stating their effect in general terms on such properties as structure, mechanical properties, machinability, wear resistance, heat resistance and founding properties. The real meat is to be found in Chapter III, for herein are detailed the influences of elements on sixteen properties of cast iron, ranging from tensile strength to thermal expansion. We suspect that there has been a looseness here in the use of the word "alloys" instead of "elements," but perhaps the Editor had in mind that it is as an alloy that the element functions.

The logic of the book may be questioned on theoretical grounds for next dealing with alloy white and chilled cast iron, but there are good sound practical reasons for so doing in this case. In America there is a very large business undertaken for the production of chilled "car" or railway-truck wheels. So big is it that the manufacturers have organised their own co-operative research laboratories. The key to the general present-day inadequacy of alloy cast-iron research is provided by a chapter on the heat-treatment of alloy cast iron. It is obvious that the discrepancies in published results are too often correlated with compositional differences instead of thermal history. Whilst obviously the founder is *force majeure* interested in the properties related to the as-cast condition, yet probably a quicker road to a general and better appreciation of the effects of alloy additions would be to obtain them from normalised samples. Moreover, there *is* something in our recent plea for a standardised method of moulding test-pieces. From now onwards, the book gets right down to the foundry floor, and gives many useful hints as to gating, risering, ramming, the methods to be used for adding the various elements, and so forth. No less than nineteen pages of tabular matter are included to detail suggested compositions for every type of engineering application—a remarkably useful and satisfying piece of work.

We think we can just detect—and we want to be very polite and encouraging—the beginnings of *rapprochement* in nomenclature and the mode of digital expression, not only in this book, but in American foundry literature in general. For instance, the first paragraph of Chapter V uses the expression "quenching and tempering," but later the word "draw" figures fairly generally. Again, in perhaps 5 or 10 per cent. of the cases, Centrigrade readings are given. We wonder if during the forthcoming International Congress we could come to terms on some of the following points: temperature readings; tensile properties; niobium or columbium; drawing or tempering, top and bottom boxes or cope and drag. We would readily jettison "top and bottom boxes," for accommodation in either temperature readings or "tons per square inch." However, this is extraneous to the major subject of the book. The conclusions we have reached are: (1) The volume adequately portrays the existing state of the art. (2) It discloses the need for retraversing certain ground (*e.g.*, effect of manganese on hardness), as there is too little agreement in published work. (3) It discloses the necessity for new research to be done, with additional elements and extended work on currently used ones. (4) It emphasises the really wide commercial use which has been made of alloy cast iron. (5) It indicates a scope which so far as this country is concerned has only been touched. (6) The bibliography discloses that United Kingdom research workers have contributed a very useful quota to the general progress registered in this field.

* Published by the American Foundrymen's Association, 222, West Adams Street, Chicago. Price 3 dollars.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

A New Steelmaking Process

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In the article which appeared in your issue dated March 23, entitled "A New Steelmaking Process," mention is made of fettling the hearth of a rotary furnace. I should be interested to learn how this is done.

I am operating a 5-ton Brackelsberg furnace and have also operated a Sesci furnace of similar size; in both cases I have found that, on the day following a melt, the interior of the furnace was too hot to permit a man to enter—even John Chinaman, who is a willing and hardy worker, finds it so.

I gather that at Crewe the furnace is fettled on the day after each melt. Is the refractory applied by some externally operated mechanical means, or does the workman enter the furnace and either daub or ram the refractory?

May I also take this opportunity of sending my "chin-chins" to all the friends I met at Bradford last June? I shall be pleased to hear from them at any time, and if it should so happen that any foundryman might pass through this colony, I hope I shall be given the opportunity to entertain him.—Yours, etc.,

S. SIMPSON.

The Laboratory,
Taikoo Dockyard,
Hongkong.
May 3, 1939.

[We thought that we had made it quite clear in our article that the system employed at Crewe is, immediately after casting, to drain the furnace well of steel and then to select an area, say one-fifth or one-sixth, of the internal circumference and to frit on a few inches at the maximum depth. After the next cast or next day another area is selected and built up, so that by working methodically the whole of the lining lost by erosion or slag action is replaced. We are perfectly sure that correspondence addressed to the Works Superintendent at Crewe will be productive of any practical hints requisite to ensure success.—EDITOR.]

Some Impressions of American Enamelling Practice

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Under the sub-heading "Porcelain Enamel & Manufacturing Company," the author of the above article (Mr. Gray), in your April 6 issue, mentioned the type of our equipment, but unfortunately underestimated its size. We will greatly appreciate to have Mr. Gray's statement corrected, by informing your readers that our Pemco plant actually contains four continuous-type smelters, five rotary smelters and two box-type smelters.—Yours, etc.,

A. KELLNER,
Export Manager,
The Porcelain Enamel & Mfg. Co.

Baltimore,
Maryland.
May 2, 1939.

The I.B.F. Annual Golf Meeting

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—The Golf Committee are pleased to announce that this year's meeting has been fixed to take place at Brocton Golf Club, near Stafford, on Sunday, July 2.

Brocton is a well-known Midland course, and will prove full of interest to our potential tigers, and yet is not too difficult for the long handicap men. The 19th hole is particularly well catered for. The T. G. Bird Challenge Cup will again be up for competition, and Mr. J. E. Hurst has again signified his willingness to present a tankard for the winner of the competition on the lines of last year.

Would intending competitors please write to Mr. James Bell at the address below for entry forms, if they have not already received full particulars? It is expected that the inclusive cost for green fee, lunch and tea will be approximately 10s. per head.

Inquiries are being made for suitable accommodation at the hotels in Stafford, so that special terms will be obtained for competitors who care to stay over the week-end.—Yours, etc.,

J. BELL, J. GARDOM, R. A. STILES,
D. H. WOOD, A. G. ROBBIETTE
(Committee).

Somerset House, Temple Street,
Birmingham, 2.

Catalogues Received

Core-Making Machinery. We have received from the Constructional Engineering Company, Limited, Titan Works, Birmingham, 12, an advance copy of a folder designed to bring strikingly to the notice of foundrymen a new design of core-blower. The front cover emphasises by three indications the exceptional speed to be associated with the new machine. There is the "flashed" headline "No Speed Limit"; a de-restriction sign and a speedometer from which emanate rays detailing the striking example of bibcock cores, where a tenfold hourly production is claimed. Any one of these is an excellent publicity notion, but by utilising three there is a tendency to unnecessary complication and perhaps confusion. Moreover, additional implications are inferred by the interconnection of the open road and the "Titan way." The interior make-up and especially the letterpress are both excellent, and the illustration of a very large number of cores, with indications of their hourly output, is a commendable way of demonstrating the potentialities of the machine. As soon as this folder is off the press it will be available to our readers on application to Birmingham. As the technical matter has been well chosen and set out, it makes a worth-while addition to one's collection of trade literature.

Mould and Core Drying. A catalogue of outstanding interest to the foundry industry has just been produced by the Foundry & Engineering Company (West Bromwich), Limited, of Sandwell Road, West Bromwich. It confines its contents to the "Acme" pressure system as applied to the batch method, to the complete exclusion of the continuous method. Included are two interesting graphs showing the benefit derived in one case from a changeover from natural draught firing to pressure drying. The gap between stove and mould temperatures is materially reduced. Additionally, details are given of a frictionless bogie, and its utility is shown by a claim that a full load—something of the order of 80 tons—can be handled without the aid of mechanical power by two men. The catalogue takes the form of an eight-page booklet.

Erith Loam. An eight-page booklet received from J. Parish & Company, Limited, of Erith, Kent, shows in a remarkable fashion the ancient and modern in foundry practice. In the foreword the story is told how, probably, a hundred years ago, a South Shields foundryman discovered that the "ballast" tipped up on the quayside was a fine type of loam. In the pages which follow are set out the mechanical, physical and chemical analyses of the various grades quarried. Only a decade or two ago, the majority of the figures disclosed would have been as intelligible as Chinese to the average foundry executive. Now, they are in many cases essential figures for adequate process control. The dual interest this booklet displays makes it a publication of distinctly useful character.

Random Shots

After the rush of an International Congress, as anticipated by even a cursory glance at the official programme, amidst the roar of London, many worn-out "Congressites" will long for a quiet holiday. What promise of solitude and rest then, there lies in the names of "Johnnie All Alone," a remote spot in Essex, and in "Finemeoot" in Scotland! Unfortunately, Johnnie is so alone that he could not afford a night's lodging and Finemeoot, when you have accomplished it, is nothing but a row of miners' cottages. So it will have to be Blackpool, Brighton, or Blankenberghe, after all. Strange how many of the brighter holiday resorts begin with "B." That is, of course, because it acts as a natural prelude to the "C"; and yet, oddly enough, the question one repeatedly finds oneself asking, after having chosen one such place to go to, is "Y"?

* * *

Foreign visitors to London are earnestly requested not to take our language too seriously. Otherwise they are in danger of contracting *le vertige* over such gems of inverted syntax as these:—Notice in a shop window: Sale of shirts, which will last for one week only.

Instructions on a tin: Heat gently on stove after adding well-beaten egg. N.B. Egg can be omitted if liked.

Another kind of English, calculated to turn the brain of any young English works manager out in the East, has been sent to "Marksman" by Mr. Sidney Simpson, of Hong Kong.

"I have," writes a Chinese employee, "the honour to inform you that I have got fever, stomachache, diarrhœa for a week before, but I don't fear with them until last day morning (27th) I feel it is not disturb with a long time and I have no got the leave to stay less you know. So when I come back from the dockyard at evening (27th) the sicks are distending to the hold of the body and then unconscious. Because that I at once got to see the Chinese Doctor with my mother, he said that I have been got the scar on the lung and it scampered, so he write some medicine taking at 8 o'clock a.m. (28th). It is very tire of the limbs and I have no might to walk and standing. So I sent the bearer take this bad news and also hope you will kindly stay at home for a day, sooner I would gotten better, I would must begin my work. I think that you and Ah Leung are not like to hear of this, please pardon me. Goodbye!!!"

* * *

In time, of course, he can read it just as easily as the school teacher reads those proverbially misleading letters explaining the reason why Mary can't come to school to-day; or with the same power of interpretation as the City merchant whose Paris representative 'phoned to say that he couldn't keep his appointment in London as he was suffering from a very bad "cow on the box."

* * *

Never expect a man to solve a crossword clue which in any way appertains to his trade or profession. An otherwise clever metallurgist recently missed these two clues on consecutive days:—

Clue.—You can't say this leaves no trace.
Answer.—Carbon.

Clue.—A tea-thing in faces is bound to get hot.
Answer.—Furnaces.

* * *

Lot 9 from the Barrington Hooper Collection.

After burying the hatchet, don't mark the spot.

Many a home is ruined by the husband backing horses and many a garage by the wife backing cars.

"MARKSMAN."

Cupola Control

By H. P. HUGHES

Introduction

Hurst, in a recent publication, made the following remark:—"It is very interesting and very significant that the scientist is at last recognising the importance of cupola melting conditions." No doubt he included all the factors that tend to give satisfactory melting. The cupola is still the most widely used, the most satisfactory, economic and speediest unit for the production of cast iron, yet the best results can only be obtained when every section of the practice is properly controlled.

The purpose of this Paper is to set out some principles which will assist in the mastery of the cupola; this, it is suggested, will only be obtained when a recognised system of control is in operation. Even to-day, with the abundant supply of information at the disposal of all, there are many foundries where little attention is given to the working of the cupola. Practical experience plays a very important part in its successful operation.

There are, no doubt, certain rules which can be applied and made use of, but one does not have to travel far to find that similar results can be achieved with a certain measure of variation in operating conditions. Probably herein lies the success of those foundries which have no system of control. The objective is to postulate some principles and methods which have proved to personal advantage in relation to the cupola; at the same time it is recognised that each cupola is a problem by itself and accordingly the practice and details of each must be taken into account.

At the Grangemouth Iron Company there are three cupolas, two of similar construction which are in operation on alternate days, and a small one which is used periodically for special work. The large cupolas are 4 ft. 9 in. inside diameter at melting zone. The charging door is 19 ft. from the hearth, being suited for mechanical charging. On account of this, it is necessary to keep the level of charges 3 to 4 ft. below the charging door level, thus giving a working level of 15 to 16 ft. above the hearth. The wind belt is of exceptionally large capacity, 4 ft. 6 in. deep by 15 in. wide. The main tuyeres are below the wind belt, and the auxiliary tuyeres inside. There are eight main tuyeres, the size of which is 8 in. by 4 in. splayed to 9 in. by 5 in.; there are also three rows of auxiliary tuyeres 1½ in. dia., splayed to 2 in. dia. The main tuyeres are 2 ft. from the hearth and the auxiliary 18 in. above the main tuyeres. The two top rows of auxiliary tuyeres are not now used.

The small cupola is 3 ft. 2 in. dia. at the melting zone. The charging door is 18 ft. 6 in. from the hearth. The wind belt is 2 ft. 6 in. by 6 in. wide. There are two rows of main tuyeres in the wind belt, four in the first row 8 in. by 4 in. and three in the second row, 5 in. by 3 in. The first row is 2 ft. 7 in. above the hearth, and the second row 8 in. above the first.

Preparing the Cupola

Most foundrymen have come to realise the advantages to be gained by a good coke bed. A coke bed properly prepared and conditioned is the basis of successful melting; it is well known that, should the bed fail, everything else will. Experience tends to favour a well-heated bed up to the level of the tuyeres, thus giving favourable conditions for the purpose it serves in the well of the cupola. As this section is below the level of the tuyeres, there is no other means of obtaining this condition than during kindling. There are various opinions as to how a properly prepared bed is obtained. Three methods are known to the author:—(1) Kindling and completing the bed and charging out so that the cupola can stand for some time before the blast is put on, to allow a soaking of the charges; (2) kindling and only completing the bed to charge out and put on the blast; and (3) after kindling, making up the bed as it burns through, probably by three or four additions and charging out when the bed is burning through on the top, the blast being put on immediately afterwards.

The first method will give hot metal at the commencement of the blow, but there may be a tendency to fall away as the melt proceeds, due to part of the bed having burned away. This method gives no indication of the condition of the bed. The second method tends to give cold metal at the beginning. In this case the bed cannot be properly prepared. The last method is probably the best, because the condition of the bed is known. It is generally found that this method gives hot metal at the beginning.

It is essential that the proper height be found for the coke bed. The bed is always reckoned by height or volume, and opinions vary as to the proper height. The correct height is necessary (all other items being correct) if suitable metal is to be obtained. Too low a coke bed will result in dull metal with a high melting rate, and too high a coke bed will give the opposite results and an unnecessary waste of coke. What is desirable is the correct location of the melting zone, and keeping that zone at as nearly a constant level as possible. Should the melting zone alter, it follows that there will be an alteration in conditions in the cupola.

The level is found to vary from 2 ft. 6 in. to 3 ft. 6 in. above the tuyeres, depending to a certain extent on the blast pressure (the height increasing as pressure increases), and to a less extent on the size of coke, small coke giving greater resistance and reducing the required height. The author is inclined to favour a slightly higher bed than is theoretically required, as it gives hotter metal at the start of the cast, resulting in the use of metal which would, as a general rule, be put in the pig bed. The use of this metal compensates for the extra coke required.

Charging

The method adopted in most foundries is to charge the pig-iron first, placing it more to the outside than the centre, with the scrap on top. Probably this method gives the most satisfactory means of obtaining equal melting of the charge. The weight of the iron charge and the amount of fusion coke required per charge are important points. Some foundries make the metal charge correspond to the amount that is run off per tap, or the amount that the bogey holds, and in this way obtain a homogeneous mixture. Again, it may be necessary to make the charge suit the capacity of the wells. These methods work satisfactorily in many cases, yet they are not the most important when considered in relation to the control of the cupola. Too light charges mean a shallow coke charge, which tends to give oxidised metal; on the other hand, too heavy charges tend to give dull metal, owing to the bed burning low before it is replenished by the following coke charge. A good metal charge is a weight equal to about one-tenth the hourly melting rate of the cupola. There should always be a layer of coke between the charges from 6 to 8 in. in depth. To obtain a proper separation of charges, the weight of iron should be arranged to give this amount. The cupola should be charged to such a height that full advantage is taken of the heat in the ascending gases. The brickwork at the charging level should not exceed a dull red heat till the blow-down.

Standard charging methods should always be carried out to give regular working of the cupola. Trouble may result with erratic methods of charging, both in respect to the distribution of the blast and the mixing of the metal.

For proper control, all materials charged should be carefully weighed. The advantage of this procedure cannot be overstressed; it is essential for regular running of the cupola and control of metal composition. Both pig-iron and scrap should be weighed separately for each charge. Coke may be either weighed or measured. Weighing is suitable if there is not a large variation in the moisture content, but the latter can vary considerably. In dry weather it may be as low as 1 per cent., and in wet weather as high as 12 per cent., thus causing a marked variation in the available carbon. Measuring the coke if it is regular in size is also very satisfactory. Here again, the measure will vary with different sizes and blends of coke. As measuring is the method personally adopted, this fact was strongly brought out a few months ago through a change in the coke. For the first few days in which the coke was used, there was a decrease in temperature during the second half of the melt, which led to the assumption that the bed had dropped appreciably. Naturally, the coke was blamed, but further investigation showed that the new grade of coke required a greater volume for a similar weight. This will be recognised from the following specific gravity (apparent) figures:—Heavy coke, 1.12 and light coke, 0.93.

The Air Supply

Much has been printed concerning the profound influence which correct blast plays in the success or otherwise of cupola operation. Important improvements have been made in cupola design in recent years principally in relation to the air entering the cupola, its penetration and distribution.

The type of cupola described is of similar design to the balanced-blast cupola, but without valves to adjust the ratio of air between the main and auxiliary tuyeres. The main tuyeres are below the wind belt, which is of exceptionally large capacity. One advantage to be gained by this type of cupola is a more equal distribution of the air supply to each tuyere than is obtained in the case of cupolas with tuyeres only in the wind belt; this is no doubt a factor of considerable importance.

There is generally a difference of opinion in regard to the size and location of tuyeres. These cupolas were built with the object of obtaining better distribution of air in the combustion zone. As it is the formation of gases that produces heat, if efficient and regular working is to be obtained, proper distribution of the air is necessary. If the wear in a cupola after a blow is irregular in the melting zone, this in all probability is due to improper distribution.

The author carried out some tests on the large and small cupolas to compare the air distribution. Readings were taken with the cupola empty and the fan running at its regular load. Three readings were taken in each tuyere on the large cupola in the position shown in the key (Fig. 1); in the small cupola two readings were taken in the position noted. The main or downdraft tuyeres in the large cupola show satisfactory uniformity in velocity readings, resulting in an even melting-zone. The auxiliary tuyeres show considerable variation, but as these are not fusion tuyeres it is not detrimental. Increased uniformity in blast velocity has been found to give (1) lower coke consumption, (2) lower oxidation loss, and (3) less erosion of lining. Right-angle blast entry with tuyeres in the wind belt shows variations from tuyere to tuyere as well as across tuyeres. This proves conclusively that tangential entry of the blast with tuyeres below

D

* A Paper read before the Falkirk Section of the Institute of British Foundrymen.

the wind belt is superior to right-angle entry and tuyeres inside the wind belt.

Most foundrymen are acquainted with the function of auxiliary tuyeres in the large type of cupola. The formation of the intermediate gas, carbon monoxide, is regarded as detrimental, and as there is a certain percentage formed by the air entering the lower zone, this gas, which in the ordinary cupola would go off as waste, is utilised by admitting air at a higher level to burn carbon monoxide to carbon dioxide. Their purpose is not to form a second melting zone, as did additional rows on previous designs (except the Poumay); that is why the distance between the main and auxiliary tuyeres is fixed at a predetermined point.

Blast Pressure

Some writers lay very little stress on the pressure because it in no way indicates the amount of air entering the cupola, yet probably, because of this, its importance is lost sight of. The pressure determines the extent which the blast will penetrate in the cupola. In the past it was the opinion that a high blast pressure was necessary. However, experience has shown that penetration can equally be obtained with a soft blast. It has many advantages, including a saving in coke, through a lower bed; cooler gases leaving the cupola, and less erosion of lining. Changes in the blast pressure may be the result of irregularities in the cupola, and in this way it often proves to be of considerable advantage to attach a pressure-gauge.

The following pressures should be found suitable for the corresponding diameter of cupola:—

Dia.	Pressure (W.G.).
24 in.	12 in.–13 in.
36 in.	15 in.–17 in.
54 in.	19 in.–22 in.

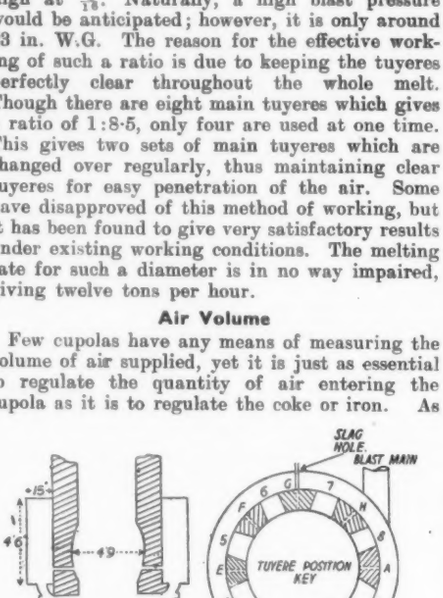
Now that the electric fan is used extensively, the blast pressure as an only means of obtaining information regarding the air supply may be misleading. The pressure can remain constant, yet there can be a reduction in the volume of air entering the cupola. A most useful instrument in this case is an ammeter. As the electric fan is sensitive to changes in the cupola, they can be noticed immediately by an alteration on the ammeter. Though it in no wise determines the amount of air entering the cupola, it does determine within reasonable limits any variation in the supply. It is often noticed during the first half-hour of a melt that there is a fall on the ammeter reading, after which it remains constant if conditions are regular in the cupola. This proves that with the more open conditions at the commencement of the blow, there is greater volume of air passing through. It is this fact that has often resulted in a change in conditions during the first hour. It is advisable therefore, if a more regular supply is to be obtained, that the valve be regulated at the beginning to give the same load on the motor as is obtained throughout the rest of the blow. This valve can be opened as the burden settles in the cupola. This will give more regular conditions during the first hour of the melt. It is not advisable to make alterations in the blast pressure during a melt, as it tends to give different positions of melting in the cupola.

Tuyere Ratio

The blast pressure bears some relationship to the tuyere area, which is related to the area of cupola. Whenever the effective tuyere area is altered, there will be an alteration in pressure. From this, one can see that although one ironfounder gets good results from, say, 18 in. W.G., with such a pressure another may be supplying twice the amount through a large variation in tuyere area to cupola area. This fact has placed blast pressure in a position of little consequence. The figures generally stated for the ratio of tuyere area to cupola area are from $\frac{1}{4}$ to $\frac{1}{5}$, the ratio increasing as diameter of cupola increases. In this respect it may be significant to mention that the working ratio on the balanced blast cupola, at Grange Ironworks, is exceptionally high at $\frac{1}{13}$. Naturally, a high blast pressure would be anticipated; however, it is only around 23 in. W.G. The reason for the effective working of such a ratio is due to keeping the tuyeres perfectly clear throughout the whole melt. Though there are eight main tuyeres which gives a ratio of 1:8·5, only four are used at one time. This gives two sets of main tuyeres which are changed over regularly, thus maintaining clear tuyeres for easy penetration of the air. Some have disapproved of this method of working, but it has been found to give very satisfactory results under existing working conditions. The melting rate for such a diameter is in no way impaired, giving twelve tons per hour.

Air Volume

Few cupolas have any means of measuring the volume of air supplied, yet it is just as essential to regulate the quantity of air entering the cupola as it is to regulate the coke or iron. As

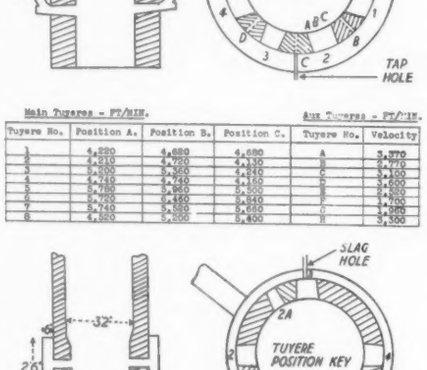


Main Tuyeres - Ft/min.

Tuyere No.	Position A.	Position B.	Position C.
1	4,220	4,680	4,680
2	4,610	4,720	4,130
3	5,200	5,360	4,240
4	4,740	4,740	4,160
5	5,760	5,960	5,560
6	5,720	5,460	5,840
7	5,140	5,360	5,660
8	4,820	5,000	5,400

Aux Tuyeres - Ft/min.

Tuyere No.	Velocity
A	3,370
B	2,770
C	3,100
D	3,600
E	2,600
F	1,700
G	1,960
H	2,300



Bottom Row Tuyeres.

Tuyere No.	Position A.	Position B.
1	4,440	4,400
2	4,360	4,360
3	4,800	4,200
4	3,940	3,400

Top Row Tuyeres.

Tuyere No.	Centre.
1A	3,460
2A	3,840
3A	3,820

FIG. 1.—AIR VELOCITIES (FT. PER MIN.) IN BALANCED-BLAST (TOP) AND ORDINARY (BOTTOM) CUPOLAS.

there can be too little or too much coke, in the same way there can be too little or too much air. The cupola will no doubt operate with a large variation in the air supply, but it is to be understood that this will cause changes in the temperature and analysis of the iron.

The quantity of air required can be found from the quantity of coke used. There is no direct relationship between the amount of metal melted and the air supply, but there is in the case of the coke, which depends on the air supply to produce heat.

If 2 cwts. of coke are used per ton of iron melted, then only sufficient to burn 2 cwts. is required. If this quantity of coke is altered, it will require a corresponding alteration in the air supply. Probably, if there were a better knowledge of the quantity of air entering the cupola, more satisfactory coke figures would be produced.

Knowing the amount of air required to burn 1 lb. of coke (generally given as 140 cub. ft.) with a carbon content of 92 per cent., a comparison can be made between the amount of coke burned per hr. and the quantity of air supplied, and the theoretical requirements.

Should the actual volume of air needed be greatly exceeded, it means that a useless quantity of air is passing through the cupola. Were this the only factor, it would not be of great consequence, but there are others even more important. The excess air will absorb heat as it passes through the melting zone, and it will also upset the actual zone, through the extra oxygen causing combustion at a higher level, thus impairing the condition of the coke when it reaches the melting zone.

With a proper air supply there should be a deficiency in oxygen in the gases passing through the charges, so that practically no combustion can take place. A simple means of showing whether the oxygen content of the escaping gases is high is the one demonstrated to boys in schools—by inserting a glowing splinter of wood into oxygen it immediately brightens up. If this takes place, it is evident that there is a considerable amount of oxygen in the escaping gases supporting combustion. The serious effect of oxidation is often the outcome of excessive air.

Should the quantity of air be less than that required for complete combustion, this will evidence itself also. Dull metal will be produced because maximum combustion cannot take place, and following this a reduction in the melting rate will result.

Under normal conditions, the melting rate will show if the correct quantity of air is supplied. The sectional area of the cupola determines the melting rate, and with satisfactory conditions it should be from 15 to 16 cwts. per hr. per sq. ft. of area at the melting zone. The melting rate, however, needs to be considered in connection with air volume and coke consumption, as any alteration in one or the other will alter the melting rate. Insufficient air will also result in a high loss of available heat through the escaping gases containing a high CO percentage.

Regular melting conditions are important, and can only be arrived at if a proper zone is maintained. Any deviation from this will be evidenced as the cast proceeds through certain changes that take place. There are several reasons that can be put forward which alter conditions.

Primarily the correct quantity of coke per charge is required. Too little will cause the coke bed to burn low and thus reduce the melting zone, whereas too great a quantity will increase the effective height of the bed. One of the most accurate means of determining change in this respect, which has been found to be reliable, is controlling closely the melting rate, a high rate indicating too little coke, and a slow rate too much, all other things being regular. Again, these changes are generally followed by changes in the temperature of metal tapped.

Other reasons of less importance are obstructions in the tuyeres, and distribution of the air. Too large a slag hole allowed to remain open for a considerable time may also cause a disturbance, as the melting zone is fixed by the tendency of the air to travel inward and upward, and the easy access of air through the slag hole will allow a considerable amount to be lost.

Combustion

The products of combustion are well known. It is a fact that 1 lb. carbon burning to carbon monoxide only produces 4,450 B.T.H., whilst 1 lb. carbon burning to CO_2 produces 14,550 B.T.H. Thus two-thirds of the heat may be lost by incomplete combustion, which will greatly reduce the efficiency of the cupola. Numerous methods have been put forward to obtain the full advantage of heat transmission to the metal for melting and superheating. Principally, there are two methods now available:—(1) A single row of tuyeres which is expected to burn carbon to CO_2 at the one level, and (2) the other supplying air at a higher level to burn CO formed by air supplied at a lower level.

Carbon can burn in either one or two stages, direct to CO_2, or to CO and then CO_2. Many writers have advocated complete combustion to CO_2 to produce maximum heat, maintaining that in first forming CO, and then CO_2, the same efficiency is not obtained. However, to obtain maximum combustion, excess air is required. It is well known that CO_2 is formed during combustion in excess air, whereas CO is formed in a limited supply of air. It may have been with this object in view that Fletcher designed the balanced-blast cupola, having the air entering the main tuyeres under control. Most of the efficiency in the cupola is lost, not so much by burning CO to CO_2, but rather the reduction of CO_2 to CO, since, instead of heat being generated, it is absorbed. The possibility of this occurring with a single row of tuyeres is greater than with the extra auxiliary tuyeres.

The efficiency of the cupola can be greatly impaired through a high loss of available heat, one of the sources being the escaping gases passing off at a high temperature. As high as 10 per cent. CO is regularly found in the escaping gases. Over a period of six months, the highest CO figure obtained in the balanced-blast cupola under the author's control was 2.5 per cent.

Fuel for Combustion

Coke contains carbon in a very satisfactory form for use in the cupola. Although it is principally carbon, it seems to have some interesting characteristics which produce varied physical properties with different blends. This has resulted in classifying cokes in relation to their suitability for cupola use.

An ironfounder may try a few blends before he finds one giving him satisfaction. As a rule he generally keeps to it. In this respect, English and Welsh cokes have gained preference over Scotch. A personal opinion is that good results with these cokes brought about slipshod control of many cupolas. There was a day when hot iron was the whole concern of the ironfounder, without consideration of the cost at which it was obtained. To-day, however, he is realising the waste through lack of proper control. With this control it may be possible that cokes, at one time looked upon as a source of trouble, will produce satisfactory results. Proper control has enabled the author to use Scotch coke successfully.

Control of Pig-Iron and Scrap

Control of pig-iron is in a measure possible, as most suppliers are able to give analyses. Yet it has surely been the experience of most ironfounders, at one time or another, to discover his trouble brought about by an unknown change in the pig-iron. This has been personally experienced several times in the past year or so, and as a result, it has been found a wise policy to analyse all pig-iron before use.

One instance is of a certain type of casting which, after having been made successfully for a considerable time, began to show regular trouble through springing. After a full investigation, the following conclusions were drawn. On analysis of the sprung casting, it was noted that the manganese content was very low—below the requisite balance for the sulphur content. Again, the castings were produced with metal run during the blow-down. An analysis of the pig-iron charge was made, and the manganese content was found to be 0.2 to 0.25 per cent.; this was abnormally low, without even considering loss in melting. Since there is a tendency for oxidising conditions during the blow-down, it reduces this figure, thus producing a very weak iron. The pig-iron was sold as 0.4 per cent.

A somewhat similar case was brought to the author's notice at this particular time. An ironfounder engaged in the production of baths had to scrap all his pig-iron and order a different brand to eliminate heavy losses brought about by springing in the enamelling process. All this proves that, despite the makers' figures, pig-iron analyses should be regularly checked.

In the case of scrap of an outside nature, there cannot be the same control. Here, again, complete understanding of the pig-iron used can make good most irregularities that may be found. The old method of mixing by using so much No. 3, so much No. 4, plus so much scrap, is fast dying out.

Now that machine-cast pig-iron is being more widely used, the possibility of success with this method is altogether hopeless, as the fracture in no way indicates the composition of the iron. This surely necessitates rigid specification from the pig-iron manufacturers, plus analysis on the part of the ironfounder.

Limestone

There are varied opinions as to the amount of limestone required, and no stated figures can be accurately given. A generous supply should be used to obtain a fluid slag which will facilitate cupola operation. The constituents of the slag other than lime are gathered from the ash in the coke, sand on pig-iron and scrap, rust on scrap, the refractory used for lining, and the oxidation of the metal and its constituents, so that the amount required depends on the amount of these constituents that need to be fluxed.

It is personal practice to use 50 lbs. of limestone per charge of 180 lbs. of coke. This may be higher than normal, but the method of working calls for it. As the scrap is lifted from the floor and put in a container, where it remains till it is tipped into the cupola, it means that more sand is associated with it than if it were handled once or twice, thereby necessitating a higher addition of flux.

The slag should be fluid enough to flow freely from the slag notch, whether for continuous or periodic running. Too high an addition will have an erosive effect on the lining. Too low an addition will give a gummy slag which may retard combustion through adhering to the coke, and its desulphurising effect will be of little consequence. A fluid slag is a better desulphurising agent than a viscous one. Limestone addition should start with the bed if it be desired to get the lowest possible sulphur pick-up at the start of the melt. It is generally assumed that the first iron tapped from the cupola is richer than the subsequent iron, and it is because of this that the metal from the first tap is often discarded. Very often the first tap can be put to use if an addition of flux is placed on top of the bed.

Tests were carried out to find if there was any difference with this addition. On the first and second day, limestone was not put on till after the second coke charge, but on the third, fourth and fifth days, limestone was placed on the bed and subsequent charges. The amount of scrap used on the first charge is the same as for the rest of the cast:—

		1st bogey	4th bogey
1st day	Without limestone	0.091	0.062
2nd ,,		0.095	0.067
3rd ,,	With limestone.	0.082	0.067
4th ,,		0.085	0.066
5th ,,		0.079	0.071

This shows a lowering of the sulphur with a limestone addition, and it goes to prove that limestone has a desulphurising effect on the iron. Fletcher states that the desulphurisation effect of the slag is negligible if it contains less than 30 per cent. lime. However, these tests were carried out with a lower figure. Also, there is a certain amount of ash formed during the preparing of the bed which will be removed by an addition of limestone on the bed.

The appearance and analysis of slag can often determine the prevailing conditions in the cupola. High iron-oxide content indicates oxidising conditions. Under good conditions a slag may contain 10 to 15 per cent. iron oxide, and in a strongly oxidising atmosphere it will rise as high as 25 per cent. This loss in iron is not marked, but with the oxidation of iron there is that of manganese and silicon, and when it is realised how small a percentage of silicon and manganese there is in iron, it will be appreciated that any loss is bound to show a considerable difference. A slag high in iron oxide may be also due to the use of rusty scrap. Iron oxide, as well as tending to oxidise the silicon and manganese, has a very strong erosive effect on the lining of the cupola.

The colour of a ground sample will give an approximate idea of the iron-oxide content, the colours ranging from light green to greyish black as the iron oxide increases.

Changes in the Cupola

Conditions in the cupola can to a great extent alter the composition of the iron. It is possible with bad cupola practice to produce a grade of iron in no way comparable with the iron charged. Probably if there was available a more intimate knowledge of the changes in the cupola, foundrymen would be well on the way to solving many of its problems.

The three recognised zones in the cupola are:—The stack, which contains the descending charges; the melting zone, where combustion of coke and melting of iron take place, and the well, where the metal and slag collect. Of the three the melting zone is by far the most important, and the one where the changes take place to a marked degree. The changes in the cupola are mainly due to the oxygen of the blast and its reaction with the coke, the fluxing power of the flux and the temperature of the combustion zone. The most important changes in the iron are the absorption of carbon and sulphur and the oxidation of Fe, Si and Mn.

Carbon is the most important constituent of cast iron, and it is the one that is most difficult to control, especially in the graphitic form. The properties of cast iron depend mainly on this constituent, its presence or absence, its form and distribution. Carbon pick-up has always been a problem, as there are so many variables associated with it. It is referred to as carbon pick-up because it is the quantity of carbon absorbed by the metal in contact with the incandescent coke. It varies with different conditions, and types of fuel, height of bed and temperature of combustion zone all affect the carbon. Generally speaking, small coke increases the pick-up, as the metal will come more in contact with the coke. A high coke bed and high temperature increase the carbon pick-up. Bamford's work suggests that control of carbon lies principally in the height of bed, size of coke and quality of scrap. Experience seems to show that no carbon is absorbed in the well, probably due to the fact that the temperature is too low.

Sulphur

Sulphur has a very strong chilling and hardening effect on cast iron, and as a result a high percentage is not desirable. However, it is not now regarded as troublesome as it was at one time, because of a better knowledge of its formation in the iron; this allows the use of a sulphur figure which in the past would have been considered dangerous. It is, nevertheless, desirable to keep it as low as possible. The sulphur pick-up depends on the sulphur content of the coke, and particularly on the form in which it is found in the coke. Pearce suggests that there is a relationship between the sulphur pick-up and the combustible sulphur in the coke. It is therefore advisable to have as low a sulphur content in the coke as possible, as the sulphur pick-up may vary from 20 to 50 per cent., depending on the sulphur content of the coke.

Sulphur must be considered in relation to manganese, for the former can be present in two forms, depending on the manganese content. When the manganese present is insufficient to combine with all the sulphur to form manganese

sulphide, then iron sulphide is formed. Manganese sulphide is insoluble in iron and has very little effect on its strength. Iron sulphide, on the other hand, is present as a eutectic of iron and is relatively weak, and has a weakening effect on the iron. Therefore MnS is much to be preferred to FeS. To obtain the desirable manganese sulphide it is necessary to have manganese in excess of sulphur, because iron has almost as great an affinity for sulphur as manganese. Theoretically 1 part of sulphur requires 1.7 parts of manganese to form MnS, but this combination does not take place till there is approximately 0.3 excess manganese.

A good way of keeping the manganese content at a satisfactory figure is the use of a high-manganese pig-iron, somewhere in the region of 1 to 1.2 per cent. Personal experience has found it to give very good results. It is much handier to use than ferro-manganese and there does not seem to be the same loss. It is very useful also for increasing the percentage of scrap. With good conditions the loss by oxidation of manganese should not exceed 20 per cent. As there is a loss in manganese and a gain in sulphur going through the cupola, it is necessary to allow for an excess of manganese in the metal charged.

Silicon

There is an oxidation of silicon during melting, probably up to 5 per cent. Silicon is the predominating element in determining the relative proportions of combined and graphitic carbon. Generally speaking, the lower the silicon the higher the combined carbon and lower graphitic, and the reverse with increase in silicon.

Phosphorus

The phosphorus content is slightly increased during melting. It assists greatly in adding fluidity to the iron, and on this account is used extensively in light castings. It is present in iron as phosphide eutectic which has a weakening effect on the iron.

Oxidation

This may be attributed to bad melting conditions, in which respect, the following can be cited:—Excessive blast, low coke bed, or low coke charges for the blast used. Where it is evidenced in a marked degree is the rapid cooling in the bogey as the metal is being cast. There are other characteristic features which prove excessive oxidation in the cupola:—(1) Ebullition or sparking in the bogey; (2) the pouring heads of castings, and (3) the examination of a chill test-piece, where its appearance is unmistakable.

Dissolved iron oxide has a marked effect on the physical properties of the iron. The transverse strength is lowered and the deflection is greatly reduced. To a certain degree it affects all elements, reducing carbon and sulphur pick-up and giving greater loss of iron, manganese and silicon.

An endeavour has been made to show a few of the more important factors in cupola control. It is a well-beaten track, but much remains to be done. Though one often fails to reach a higher standard of control, even in the failure much knowledge may be gained.

(*Continued from next column.*)

showing must be firmly stopped up by rubbing over the face of the mould with a flat piece of cork or wood. This is important, as an open vent can cause a small "scab." A good plumbago is dusted on and the face lightly sleeked.

Four spray ingates are cut in the flange, about 1½ in. wide and a bare ⅛ in. thick. A riser is placed on top to ease the strain. The sand is worked on the dry side, and it is important, when pouring, to keep the bush full of metal until it shows in the riser. It takes about a hundredweight of metal to cast each pan, and a close-grain iron is used.

Moulding Cast-Iron Cooking-Pans

The cast-iron cooking-pan shown in Fig. 1 is used in the cooking of fish and chip-potatoes. Though displaced to some extent by welded steel pans, they are still called for where coal is used as a fuel in preference to gas or electricity. The use to which this type of casting is put demands perfection in moulding, and nothing less will be accepted by the castings inspector. The smallest "scab," or any suspicion of dirt on the bottom of the pan is a sure passport for its banishment to the scrap heap. The reason lies in the fact that any percolation of boiling fat, however small, through the bottom of the pan on to the fire underneath would cause a sudden blaze, with the attendant danger of the cooking-range catching alight.

The iron pattern, which is moulded in green-sand in a three-part box, fits into a strong wooden turn-over frame. Facing sand is then sieved inside the pan and floor sand riddled in to the depth of five or six inches. It is at this stage that the utmost care must be taken in

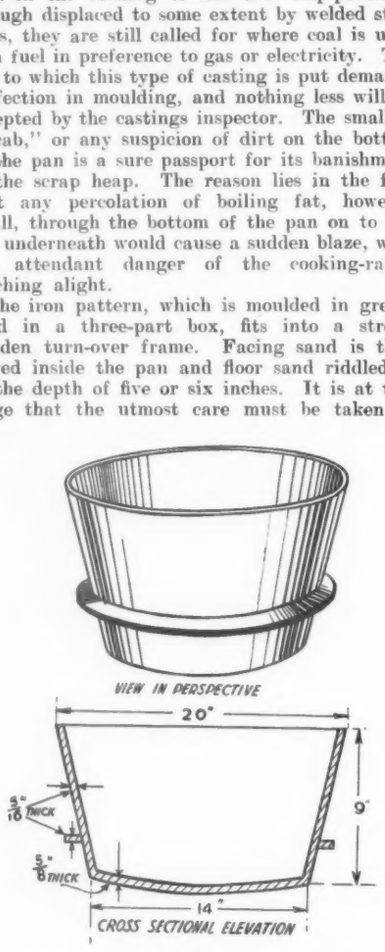


Fig. 1.—Cast-Iron Cooking-Pan.

ramming; hence the spade handle is used for that purpose, the reason being that, by means of its broad surface, the sand can be rammed tight without fear of being too hard on the face of the mould, yet it will be sufficiently solid to withstand the pressure of the iron, thereby eliminating the risk of uneven thickness. An iron rammer, with its tapered end, if used without extreme care would strike too near the pattern, causing hard spots, with the resultant "scabs." The iron rammer can be used for the next courses of ramming.

When the inside is rammed up, the middle part is put in place, rammed to the top with riddled sand, the joint made and parting sand sprinkled on. The inside of the pan mould is then well-vented, care being taken not to strike the pattern with the wire. The bottom part is fitted on, rammed up and a handful of sand scooped out of the centre of the box. The cavity thus made acts as a reservoir for the air and gases, allowing them to "hang" until they make their escape. The scooped hole is then vented sideways and downwards so that the wire contacts the previously-made vents.

The job is then turned over, and the bottom part vented underneath, the vent wire reaching to the cavity. The top is rammed up, the pattern withdrawn and the mould finished. In finishing the bottom part of the mould, any vents

(*Continued in previous column.*)

Permanent Magnets

Hans Legat, in the course of a communication to "Metal Progress," on permanent magnet alloys, states that in less than ten years the magnetic alloys invented by Dr. T. Mishima have had an outstanding development. Researches by different investigators on the microstructure have given one a clear idea of the mechanism of their mechanical hardness and magnetic power. These phenomena appear to be associated with the precipitation of crystals, which in the state of greatest magnetic hardness are scarcely visible under the microscope. The speed with which this crystallographic separation proceeds is somewhat low, yet the degree of undercooling of the parent solid solution is of particular importance. In the iron-nickel-aluminium alloys free from copper and cobalt the highest magnetic power is secured only in an intermediate state between the full suppression of reaction (fixation of unstable solid solution) and the beginning of visible precipitation. Such a state demands a carefully-controlled cooling, as in a blast of air.

Melting is preferably done in acid-lined, high-frequency furnaces and demands special operating conditions because of the reaction between metal and furnace lining. If a basic refractory is used, an aluminium-rich accretion grows excessively on the furnace lining. If the component alloys are melted separately and added in a mixing ladle, aluminium shows a positive heat reaction on mixing. The castings are poured advantageously, but not exclusively, in green sand moulds.

The exact alloy used depends on the desired magnetic properties; usually excellent values can be had from the ternary iron-nickel-aluminium alloys in the as-cast condition, by simply harmonising the composition with the mass of the casting. Values so achieved are scarcely surpassed after special precipitation hardening. An alloy containing 25 per cent. nickel and 15 per cent. aluminium in pieces of about ½ in. wall thickness may have, in the as-cast condition, residual magnetism of about 5,600 gauss with coercive force of about 500 oersted, while after the most favourable heat-treatment they showed 6,200 gauss and 495 oersted. Some idea of this superiority may be had from the criterion proposed by K. L. Scott, namely, that the product of residual magnetism by coercive force can be used as a measure of magnetic quality. This product for the standardised chromium magnet steels is about 625,000; for the best commercial cobalt steel quoted by Scott it is 2,300,000; for the Mishima alloy as cast 2,800,000; and in the heat-treated condition, 3,070,000.

With further additions of cobalt or copper or both, the iron-nickel-aluminium alloys show a more complex and easily observable mechanism of precipitation hardening. As cast, these alloys are not useful because of their low magnetic values, and they always require a double treatment composed of an accelerated cooling and a precipitation anneal. The necessary cooling speed increases with the cobalt content. With more than 5 per cent. cobalt, further cobalt additions are less effective than copper.

As to the magnetic power, an alloy with from 5 to 6 per cent. cobalt shows from 6,250 gauss with 560 oersted, to 5,300 gauss with 760 oersted (product 3,500,000 to 4,000,000). The same alloy with a further copper addition of 5 per cent. had 5,400 gauss residual magnetism with 800 oersted coercive force (product 4,320,000).

In neither the as-cast nor precipitation-hardened condition are the alloys machinable. After a special, patented annealing treatment they become machinable by high-speed steel or hard-faced tools. Their Brinell hardness number then increases from 280 to 350, yet hard crystals and accumulations of alumina in little intergranular hollows cause rapid tool wear.

Cracking of Ingot Moulds

EXTRACTS FROM SUB-COMMITTEE'S SECOND REPORT

The Eighth Report on the Heterogeneity of Steel Ingots, which was presented for discussion at the annual meeeting of the Iron and Steel Institute in London on May 4, includes, as Section VIII, the Second Report of the Ingot Moulds Sub-Committee. This Report of the Sub-Committee deals principally with the premature failure of ingot moulds by cracking of the mould wall, as distinct from cracks which develop through disintegration of the working face. Extracts are given below.

Object of the Present Report

In the first report the Sub-Committee attempted, *inter alia*, to show the relative effect on mould life of various factors associated with the manufacture and use of ingot moulds by practical works experiments and by the examination by statistical methods of individual and collective works records. Furthermore, reference was made in that report to the two normal modes of failure of ingot moulds, major cracking and crazing, the latter being the minor cracking of the working face, and the causes and prevention of this were discussed in some detail.

Little prominence, however, was given to the subject of major cracking, which is undoubtedly the more common mode of premature failure and which can become a very heavy source of loss in the absence of scientific knowledge of the underlying causes.

The Sub-Committee have, therefore, embarked on a programme of research into the basic causes of cracking, as distinct from cracks developing through disintegration of the working face, although it is realised that in future work—and, indeed, in the notes at the end of this report, dealing with the effects of silicon and of preferential cooling on the service behaviour of the mould—these two aspects of mould failure cannot be entirely divorced one from the other.

In the present report, some distinction is made between large ingot moulds for forged products and moulds of smaller capacity used in high-production steel plants. This is due to the dissimilarity between the technique employed for large and small ingot moulds, in manufacture, design and service, which fact does not in all cases justify the making of a comparison of the performances of the two types. Despite this, however, the fundamental causes of major cracking should apply equally in the two cases.

THE CRACKING OF INGOT MOULDS

The causes of the cracking of ingot moulds are of a complex nature and no precise knowledge exists of the fundamental principles involved or of the means whereby cracking may be prevented. This is due to the complicated character of the stresses, principally thermal, to be considered, and to the difficulty of measuring them or reproducing them under controlled conditions. Attempts to prevent cracking are mostly confined to empirical alterations of design, and in certain cases this has been achieved by thickening the mould wall in the region where cracking is likely to occur.

With regard to the mould material, it is generally agreed that a very open-grained iron is less prone to cracking than any other, but even this is not necessarily true without qualification. An unduly open-textured metal, usually high in carbon and silicon, is, however, liable to premature failure by crazing, just as an unduly close metal is liable to premature failure by cracking. In the case of small moulds below about 4 tons in weight the point of highest resistance to both crazing and cracking in the most economical design possible may be reached when a mould fails by both causes at the same time. With larger moulds, however, it is desirable that a higher factor of safety against major cracking be employed, and in this connection it is usual to make the mould of a more open-grained material.

Forces Causing Cracking

An estimate of the nature of the forces causing cracking can be made from the character and position of the cracks. They may occur in many different positions, but for each type of mould the failure is usually of the same kind or of two distinct kinds; for example, a mould of a particular design may usually crack vertically on the centre line of a broad side, occasionally on the centre line of a narrow side, and rarely in any other position. In the experience of the Sub-Committee, smaller sizes of slab moulds, say up to 10-tons capacity, usually crack vertically on the broad side, while if very large slab moulds crack the failure usually takes place vertically on the narrow side.

Cracks are nearly always vertical. If horizontal, however, they can be traced usually to an obvious and exceptional cause, such as foundry faults, rough handling or poor design. To understand the majority of failures by cracking, it is necessary to study the nature and magnitude of the stresses developed under conditions of service and the ability of the mould to withstand them. Obviously, these stresses will not be as simple as the forces which can be applied to a bar in a testing machine; in fact, they are probably combinations of bend, shear and tensile stresses. Sometimes the crack will show which of these components was mainly operative, especially if it is studied as soon as it occurs, since there is a release of stress and also possible further distortion on cooling. From a study of actual failures by cracking, it is thought that the most common causes of rupture are as follows:

(1) The development of a bend stress or its equivalent (*i.e.*, tension in part of the thickness of the mould wall and compression in the remainder). This is what would occur in the simple case of a slab of iron uniformly hot on one side and cool on the other.

(2) A tensile stress in the upper (cooler) part of the mould, where the mould is not completely filled, and, to a lesser degree, at the base of the mould which is cooled by the bottom plate, or in some cases by reinforcement of the mould.

Of the mechanical tests available, the transverse and tensile tests, therefore, would seem to give the best indication as to whether or not the material is liable to crack. Tests should be carried out over the temperature range prevailing in practice.

Influence of Foundry Technique

It is a common occurrence for a few moulds to fail prematurely by cracking, while the majority of the moulds of the same design and specification may give good lives. In such cases it is often assumed that the moulds giving poor service were initially stressed and that the additional stresses imposed on them by the thermal conditions in the steelworks caused a crack. Again, there is no doubt that moulds which have apparently received identical treatment in the steelworks show wide differences in lives. Arguments set out below, however, suggest that many of the failures attributed to foundry casting stresses might be found, on closer inspection, to be due to one or more of a variety of causes, originating either in the foundry or from use in the steelworks.

It has been shown in the first report that experimental measures, such as annealing or weathering the moulds with the object of reducing foundry casting stresses, or varying the rate of cooling in the foundry, have had negative results, although it is agreed that these experiments should be extended to provide conclusive data. Also, an ingot mould is a casting of comparatively simple shape with no great variations of section, and it should not be liable to heavy casting stresses if properly made and allowed to cool in its own sand mould. Stresses might be set up by contraction of the mould on to a rigid core, but foundries, as a rule, take care to avoid this, either by providing a collapsible core or by removing the core barrel at a sufficiently early stage after casting. If the size and section of the mould limit the internal casting stresses caused by irregular cooling, and if the foundry practice prevents the sand mould from restricting the normal contraction of the casting, the internal stresses due to the foundry would be confined to those caused in service by the presence of foundry defects, such as trapped slag or sand, segregation, cold shuts, shrinkage cavities and hot tears. These are visible defects, and when detected, their influence can be estimated, but there are also other variables in the foundry, the effect of which on the liability of the moulds to crack is not at present perfectly understood. These include the casting temperature, the pouring technique and the use of different mixtures of pig-iron and scrap.

Influence of Service Conditions

A number of factors associated with casting-pit practice have an influence on the susceptibility to failure of ingot moulds, whether by major cracking or by the process of delayed cracking. These factors include:

Casting temperature of the steel.
Speed of teeming.
Time lapse before stripping.
Spacing of the moulds when teeming.
Temperature of the mould when teeming.
Direct or up-hill teeming.
Pit-casting as distinct from floor- or car-casting.
Whether or not mould filled to capacity.
Method of stripping.
Use of feeder heads.

It will be remembered that the Sub-Committee in their first report determined under certain conditions the relative importance of a number of these factors in relation to mould life, although no attempt was made to isolate as such the influence of these factors on cracking. Subsequently, however, the correlation of works records in individual cases has given information regarding the effect of certain of these factors, whilst others are still under the consideration of the Sub-Committee.

Results already obtained in this field have shown that moulds equipped with refractory heads are more liable to crack than those without; heads, part of which are introduced below the mould top, cause less cracking of the mould than superimposed heads.

The temperature of the mould when teeming also plays an important part. It will be seen in Fig. 1 that the average life of a set of 22 moulds which was given preferential cooling treatment was 24 per cent. higher than the average life of similar sets used under normal conditions. Moreover, the percentage failure due to cracking of the set given preferential treatment was considerably less than the average.

Essential Physical Properties

The stresses induced in the mould wall during and after casting the ingot arise from the differential expansion of the various parts and are determined by a measure of the elastic and plastic properties of the material and the nature

of the temperature distribution. These properties allow the mould to distort temporarily or permanently under internal stresses.

Of the thermal properties, the thermal capacity and conductivity are worthy of consideration. The first governs the rise of temperature to which the mould is subjected when it absorbs a given quantity of heat, and the second determines the rate at which heat is transferred from the ingot to the surrounding air and also the temperature gradients in the mould. Measurements of these properties taken in conjunction with thermal expansion data may throw light on the nature of the stresses existing in the mould, but no great variation in thermal conductivity and expansion can be expected within the range of compositions suitable for ingot moulds. The present position as regards knowledge of the properties desirable to guard against major cracking may be summed up as follows:

Material

To reduce major cracking to a minimum the mould material should be an open-grained hematite with relatively coarse, even graphite flakes and a ferritic matrix. This is contrary to the requirements of the mould material to withstand crazing, so that in practice a compromise is made to ensure that the matrix always contains some pearlite. The sulphur content should be as low as possible and should be balanced by enough manganese to avoid the presence of inclusions of iron sulphide, as given by the formula:

Manganese per cent. = 0.3 + 1.7 × (sulphur per cent.).

An examination of works records relating to the effect of silicon and of manganese (other than as a desulphuriser) on the mode of failure and the life of the mould was given in the first report, but the problem required further investigation before definite conclusions could be reached. The proportions of silicon to manganese are to some extent governed by the need of a matrix which is largely ferritic. As a result of further study, however, the Sub-Committee are able to include some notes at the end of the present report on the effect which silicon in the mould metal has on the life and mode of failure of the mould.

The phosphorus should be low, as it leads to the formation of brittle phosphide eutectic, but the influence of quantities up to 0.2 per cent. (excluding for safety the special case of large moulds for forgings) may not be deleterious as regards cracking, and may be beneficial in other respects.

Design

Although major cracking may be overcome by making the walls sufficiently thick, this practice is not always justified from the point of view of economy, the governing factor in many high-production plants being the weight of mould material consumed per ton of ingots cast.

Heavy lugs, abrupt changes of section, which might cause stress concentration, should be reduced to a minimum, sharp corners should be avoided, and as far as practicable the design should permit the temperature of the outside wall, during use, to be uniform.

The Sub-Committee feel that an exact knowledge of the stresses involved would permit the calculation of the correct design of the mould to avoid major cracking, but at the same time they realise that any modification of an existing design should not be attempted without due consideration being paid to the effect which this might have on the ingot quality.

To summarise, assuming that difficulties due to *premature* major cracking are eliminated, an ingot mould has the best ratio of cost to life when, in any given case, the mould fails by simultaneous cracking and crazing. If, however, in a number of moulds craze failure predominates, the mould may be made thinner, whereas if crack failure predominates, the design should be thickened until the causes of failure are approximately equal.

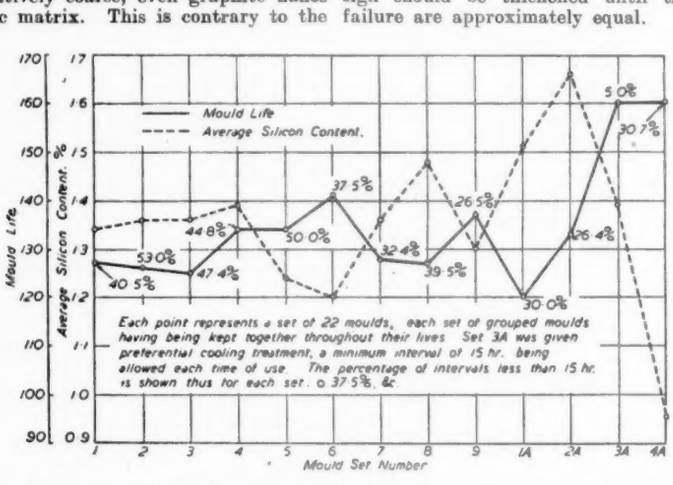

Mould Life
Average Silicon Content.
Mould Life
Average Silicon Content.
Mould Set Number
Each point represents a set of 22 moulds, each set of grouped moulds having being kept together throughout their lives. Set 3A was given preferential cooling treatment, a minimum interval of 15 hr. being allowed each time of use. The percentage of intervals less than 15 hr. is shown thus for each set. e.g. 37.5%, &c.
40 5%
53 0%
47 4%
44 8%
50 0%
37 5%
32 4%
26 5%
39 5%
30 0%
36 4%
50%
30 7%

Fig. 1.—22½-in. Semi-Closed-Top Moulds. Effect of Silicon Content and Frequency of Use.

EXAMPLES OF CRACKED INGOT MOULDS AND THEIR EXAMINATION

Examination of a Cracked 90-in. Slab Mould

The attention of the Sub-Committee was drawn by a member to a large slab mould which cracked after two ingots had been cast in it and became unusable after the third heat. This type of mould usually fails by crazing, giving a life of about 30 heats. A mould of similar design, but of less capacity (mould weight, 50 tons) used in the same steelworks, has usually failed by crazing, but has given lives of over 60 heats. The present examination was conducted with the co-operation of both maker and user, with a view to providing information which might aid in preventing similar occurrences in future.

Manufacture of the Mould.

The mixture consisted of 73 tons of No. 1 hematite iron and 25 tons of scrap moulds; 76 tons of the charge were melted in the cupola and 22 tons in a coal-fired reverberatory furnace, care being taken to ensure uniformity of composition. The mould was cast narrow end up, *i.e.*, opposite to the position when in use. The casting was allowed to cool in the pit for four weeks, and stripping took a further two weeks. Both ends of the mould were machined before use.

Conditions of Use.

The mould was designed for casting slab ingots and for use with a well bottom and feeder-head. The various capacities were as follow:—Ingot body, 60 tons; feeder head, 20 tons; well bottom, 1½ tons; total, 81½ tons.

Three ingots were cast, respectively 156 in., 160 in. and 112 in. long; the first two were full size. After the second heat, a crack was visible in one corner, and for the third heat bracing bars were placed on the short sides, but after teeming, the crack suddenly enlarged to the size shown on the scale drawing given in Fig. 2. Two-inch square bars were machined from the whole cross-section at points A, B and C.

Visual Examination of the Cold Mould

The crack extended from a position on a long side near a corner almost to the lug in the centre of the adjacent short side. The gap was about ½ in. at the top, being wider inside than outside, and the long side was displaced ½ in. outwards. The crack was slightly longer outside than inside. Short hair-cracks were noticed in all the inside corners of the mould.

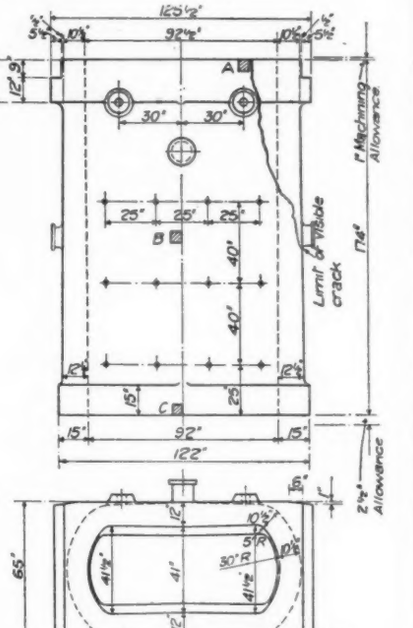


Fig. 2.—Cracked 90-in. Slab Mould.

Examination of Samples

The samples from the top, centre and bottom of the mould, as used, are marked A, B, and C, respectively (the mould was cast in the reverse position, *i.e.*, with A at the bottom).

(*a*) *Mechanical Tests.*—(i) The bars, as received, machined to 2 in. square in section, were broken in transverse, and gave the following results:—

Bar no.	Centres. In.	Breaking load. Tons.	Deflection. In.	Transverse rupture stress. Tons per sq. in.
A ..	12	4.12	0.12	9.3
B ..	12	4.11	0.12	9.3
C ..	12	8.50	0.26	19.1

The fracture of C was lighter and more evenly crystalline than that of A or B; B in particular showed dark patches.

(ii) Tensile test-pieces, ½ in. sq. in section, were machined from the broken halves of the transverse test bars; under test they gave the following results:—

Bar no.	Breaking load. Tons.	Tensile strength, Tons per sq. in.
A ..	1.88	3.76
B ..	3.10	6.20
C ..	4.965	9.93

The tensile test results confirm the higher strength of specimen C, although there is some disparity as regards A and B.

(*b*) *Chemical Analysis.*—The analysis given by the mould maker was: T.C, 3.66; Si, 1.86; Mn, 0.66; S, 0.033, and P, 0.08 per cent. This analysis in itself is satisfactory.

Drillings were taken from the centre and one edge of each of the sample bars and analysed separately, with the following results:—

	Position *A*.		Position *B*.		Position *C*.	
	Edge.	Centre	Edge.	Centre	Edge.	Centre
T.C, per cent. ..	3.77	3.70	3.83	3.62	3.80	4.35
Si, per cent.	1.83	1.81	1.88	1.81	1.88	1.90
Mn, per cent	0.73	0.71	0.81	0.75	0.78	1.08
S, per cent.	0.041	0.025	0.077	0.033	0.062	0.246
P, per cent.	0.055	0.055	0.048	0.064	0.047	0.052

Determinations underlined have been checked, and each figure is the result of duplicate estimations. Apart from the variations noted in the next paragraph, the agreement is good.

It will be noticed that there is considerable segregation of carbon and sulphur and some segregation of manganese in the centre of section C. This is undoubtedly due to the flotation of graphite and manganese sulphide after the mould was cast, C being then the top end. It might be expected that this segregation would weaken the iron at this point, but actually the reverse is the case. The reason for this will be apparent later.

(*c*) *Microstructures.*—The "feathery" type of graphite noted in A and B weakens the iron much more than the fairly uniform and randomly orientated graphite flakes in C. Thus, in spite of the higher total carbon and sulphur contents, C is much stronger than A or B.

A similar effect, though not so well marked, has been observed in other connections. Sometimes, when an attempt at producing supercooled graphite is unsuccessful, the graphite flakes are longer and very much thinner than in the original iron. Mechanical tests show that the original form is the stronger. Large clusters of manganese sulphide were present in the centre of section C. This evidence of segregation due to upward flotation supports the suggestion that graphite has also floated up. The latter phenomenon has been observed in other heavy sections, such as pig-irons, and is the cause of a change of fracture.

It seems reasonable to suppose that the difference in graphite formation is due to inoculation by inclusions or by kish graphite, such as would arise from upward flotation, although the rate of cooling, which is presumably greatest at C, may have had some effect. It is significant, however, that the points in A and B where the graphite is not "feathery" are found in the grain boundaries where the concentration of inclusions is highest.

The form of the pearlite is of some interest. In the three specimens from the centre of the mould section, and in the outside specimen, the pearlite is coarsely laminated, which is to be expected from the slow rate of cooling of the original casting. In the three specimens from the inside mould wall, however, the pearlite had recrystallised and was much finer. There is also some deposition of ferrite at the pearlite grain boundaries. The depth of this fine pearlite in section B is 3 in. to a close approximation, indicating that at least this depth has been above about 760 deg. C. Still further from the inside wall the cementite is globularised almost to the centre of the mould section. This globularised cementite tends to migrate to the grain boundaries, and this, if carried to excess, will have an adverse effect on the iron.

A long composite micrograph showed the extent to which depearlitisation and oxidation have taken place through the wall at the centre of a long side of the mould. Oxide is found up to a depth of ⅛ in. from the inner wall.

Conclusions

The failure might be attributed to the design of the mould giving an uneven temperature distribution. The masses of metal forming the bracing-bar* supports cool the short sides, which would in any case be the coolest parts of the mould. Coupled with stress concentration at the corners, this might promote a crack.

Considered also from the point of view of the ratio of the mould-wall thickness to the ingot weight, this mould occupies a position in the graph which shows that it is extremely liable to fail prematurely by cracking and suggests inadequate wall thickness.

The particular weakness, however, of the iron—the low tensile strength, etc., in the region of the crack—must be taken into account. The tensile and transverse strengths observed at this point are very low, even for ingot-mould irons. Although no practical work has been done on the correlation of the mechanical properties of mould metal with the accommodation, or resistance to internal stress, it seems reasonable to suppose that if the strength and deflection can be doubled without undue alteration in analysis, the liability of the metal to crack will be lessened. In practice, the elimination of the "feathery" graphite might be rather difficult.

Examination of Three 6½-ton Slab Moulds

Three 6½-ton swollen-sided slab moulds were submitted for inspection by a member of the Sub-Committee. Two of these had given lives of 137 and 146 heats, respectively, while the third split after 18 heats. These moulds were identical in design and made at the same foundry to the same specification. Moulds 11*B* and 24*B*, which gave the long lives, were used for floor-casting, while the other mould, 15*D*, was used in a pit.

Moulds 11*B* and 24*B* failed in the normal way by cracking on the bottom of the broad sides, developing gradually over a long period, and 15*D* failed by sudden splitting through one narrow side, also from the bottom; 11*B* and 24*B* were also badly crazed.

When 15*D* was broken under the tup, a marked variation in the longitudinal fracture appeared. At the bottom edge and for about 18 in. of the length, this was comparatively fine and even, changing to the coarse, almost fibrous fracture seen in many ingot moulds. Patches of this finer grain occurred in the centre of the section in the coarse part. The investigator did not have an opportunity of seeing the other moulds broken, but samples were taken from the top and bottom edges of each mould and examined separately.

Analyses

The analyses of the moulds were as follows:

Sample no.	T.C. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent.
24*B* Top ..	3.83	2.08	0.86	0.034	0.037
24*B* Bottom	3.52	1.96	0.87	0.017	0.043
11*B* Top ..	3.63	2.13	0.96	0.057	0.041
11*B* Bottom	3.29	2.12	0.93	0.026	0.040
15*D* Top ..	3.86	1.95	0.99	0.055	0.040
15*D* Bottom	3.66	1.90	0.95	0.010	0.043

There is not sufficient variation in the analyses to account for the wide difference in the lives of of the moulds. The higher sulphur and total-carbon figures in the tops of the moulds show the flotation of inclusions and graphite which has been observed before.

Microstructures

Micrographs were taken from the centre of the mould wall, since there was no great variation in structure throughout the thickness at the points where samples were taken. The structure of all samples except 15*D* bottom is very coarse graphite in a matrix of pearlite. An exception, taken from the bottom of mould 15*D*, showed comparatively small, thin and curly graphite flakes, associated with a denser appearance of the iron, easily visible to the naked eye on a polished section.

Mechanical Tests

A small ¾-in. dia. transverse test-piece was machined from the top and bottom of each mould and broken on 5-in. centres:

No.	Transverse rupture stress. Tons per sq. in.	Deflection. In.
11*B* Top ..	15.1	0.07
11*B* Bottom ..	19.3	0.075
24*B* Top ..	15.6	0.07
24*B* Bottom ..	20.7	0.065
15*D* Top ..	16.5	0.07
15*D* Bottom ..	12.7	0.06

It will be seen that in the two good moulds, 11*B* and 24*B*, the stronger iron is at the bottom, but in the poor mould, 15*D*, the bottom test-piece was the weakest of all. It would appear from a glance at the microstructures that this test-piece should be stronger than the others in view of its smaller graphite flakes, but the actual result shows the danger of relying on micrographs alone. It may be remembered that the large 90-in. slab mould cracked from the end which gave the weakest transverse (and tensile) test results.

The results of all transverse tests are governed to a large extent by the properties of a small volume of metal about the mid-point of the bar, and there is a danger when samples are taken across a thick section that the values obtained will not be truly representative. In this case, however, since the samples at any one section through the mould wall had almost the same structure at the centre and each edge, there is no reason to suspect the results on this account.

Conclusions

These three moulds were made in the same foundry to the same specification, and no foundry defects could be seen in the mould which gave poor service. As far as is known, mould 15D was not so severely handled in the steelworks as to account for its premature cracking. The only point brought out by the subsequent examination is the sharp and distinct variation in structure of the iron between the top and bottom, this being reflected in the transverse strengths at these points.

It has been established that a pig-iron may retain certain characteristics of its structure, in particular the size and shape of the graphite flakes, after remelting, and that these characteristics may differ for two pig-irons apparently of the same analysis. This property of persistence of structure in pig-irons, and, in fact, the structure itself, may depend on the nature and quantity of the non-metallic inclusions present. These are not revealed by ordinary methods of chemical analysis, and research is now proceeding with the object of identifying and estimating quantitatively these inclusions.

In the present instance, the three moulds are of the same analysis (within practical limits), yet mould 15D exhibits a much more marked heterogeneity of fracture than the other two. It may be that this tendency was inherited from the particular batch of pig-iron from which the mould was made, and has manifested itself under the favourable conditions of a thick section and a slow rate of cooling; these would allow non-metallic inclusions to float upwards, thus making the difference in fracture more apparent.

(To be continued.)

* The bracing bars referred to were only used after the crack had appeared, but it is now standard practice to fit bracing bars before the moulds are put into service.

Foundry Sands

CAUSES OF SCABBING

Following the presentation of Mr. Wm. Y. Buchanan's Paper on "Modern Sand Testing," a real effort was made by the Sheffield Branch of the Institute of British Foundrymen to diagnose the cause of scabbing under the most diverse conditions, by relating it to the lecturer's research work. Many useful hints were disclosed and both the metallurgist and operative should benefit by a perusal of the discussion.

MR. J. ROXBURGH (chairman) said Mr. Buchanan was to be congratulated on the amount of work which he had put into the Papers which had appeared regularly from time to time in THE FOUNDRY TRADE JOURNAL. No doubt his work had created a good deal of interest throughout various parts of the country.

Two Types of Scabs

Ironfounders were no doubt familiar with two particular types of scab, namely, what might be called the "shell" or "dummy" scab, and the ordinary solid scab. He wondered whether Mr. Buchanan could explain what caused those two types of scab. He would also like to ask Mr. Buchanan, quite candidly, if the fact that he had paid attention to his sand had helped him to eliminate scabs completely in his class of work. He was not familiar with Mr. Buchanan's class of work, but he wondered if the lecturer felt that his work on sand testing had actually helped his practice, because they knew as foundrymen, particularly with green-sand work, that much depended on the skill of the moulder as well as on the control of the sand which was used.

Finally, Mr. Roxburgh believed that, in the particular casting the lecturer had made for illustration, a green-sand core was used and the runners dropped straight on to the top of it. Of course, one would not actually do that in practice. If the casting had been run from the end Mr. Buchanan would have got quite a different result. Therefore it seemed to the speaker, as from the green-sand test, that it was not particularly effective. With dry-sand cores, however, that practice was regularly carried out.

A Difference in Nomenclature

MR. BUCHANAN thought there was really only one type of scab so-called. The one referred to as being brought into all these discussions was the so-called "buckle," apparently caused by expansion. It evidently lent itself to that explanation because of its shape, and that was the type of scab he referred to in the casting.

MR. ROXBURGH said that in one type of scab he referred to, if the sand was washed off, there was a projection on the casting, and when that was chipped off it was solid. In the other type, it was evident that either the sand had been raised, and it left a hollow, or a scab had been formed and it was chipped off, there was a hollow underneath it.

MR. BUCHANAN: The solid scab.

MR. ROXBURGH: The other one is encountered quite frequently.

Causes of Scabbing

MR. BUCHANAN said the original reason for his investigation was the appearance of scabs on a dry-sand job of considerable size, and it was cured very quickly. It would be appreciated that a cure would have to be found much more quickly than by anything of the nature he had explained. The explanation was in the incomplete drying, but fundamentally the cause was a sudden change in the dimensions and design of the job, which made additional drying necessary. At the time this trouble appeared the first recommendations appeared as to the expansion testing of sand, which until then he had never carried out. He immediately constructed something to evaluate this, and was startled to find that the sand had an expansion of 30 thousandths. He thought initially that something would have to be done, but before he proceeded much further in this direction, the foundry technique was cleared up, and it became evident that expansion was not so essential as it appeared to be. In scab formation, the cause might be ramming or the collection of steam. It was not especially permeability, because he used mostly Scottish rock sand of very high permeability. The reason for making that test core and mould exactly as he had shown was to reproduce the conditions of published work, so that he would not be talking about something different. Anyone making such a casting would obviously run it from the bottom in normal circumstances.

Questionable Foundation of Sand Testing

MR. T. R. WALKER said he had listened with great interest to Mr. Buchanan's Paper. Mr. Buchanan, as they all knew, was an earnest experimenter, and he was sure that they could trust the accuracy of any figures he obtained. To his (Mr. Walker's) mind the lesson of the Paper really was that the answer which sand testing gave them depended on the form in which the question was put. In examining sands for various properties, Mr. Buchanan showed that they received different answers according to the precise conditions of the question. In the lecturer's view certain answers were the correct ones. He (Mr. Walker) did not think that they were yet in a position to say which were right and which were not. This point, however, did not matter greatly in actual foundry control so long as consistent results were obtained from the methods used.

It was a fact that, so far, the fundamental properties of sand had not been properly investigated, and most of the experiments during the last several years had been directed to producing results which would be of immediate practical value in the foundry. From one point of view it might be said that they were building on an insecure foundation, and there was no doubt that in the future it would be necessary to do experiments on the fundamental properties of moulding materials. He was sure that, when that time came, Mr. Buchanan's pioneer work would be of great value in helping to devise scientifically sound methods of sand testing, both for green sands and dry sands.

Mr. Buchanan had queried the importance of the strength of sands at high temperatures. He (Mr. Walker) did not think that, at the moment, they were in a position to say exactly which properties of the sand influenced its behaviour in the foundry and which properties were unimportant. He, personally, would not like to say that the strength of a sand at high temperatures was of no importance in determining its foundry behaviour, but would not like to be dogmatic as to what its influence was. He considered that this was a legitimate field for further experiments.

Depth of Action Involved

MR. BUCHANAN said he would like to underline Mr. Walker's remarks as to sand being a most difficult material to test. No matter how carefully one tested it, if the test-piece was not thoroughly uniform initially, there would always be trouble. He had assumed, of course, that the mould was only affected by strength at high temperatures to a relatively small degree, that was to say, $\frac{1}{4}$ in. or so from the surface, with castings of normal size. In steel, he believed, it was more important than in iron, but the question of hot tears and so on, which appeared to enter therein, was probably better dealt with by collapsible cores, making the centres of the core intentionally weak. In testing materials at high temperature, they required to make such an elaborate set of curves representing each test that he believed at the moment, if they produced much more, they would have the foundrymen bewildered.

The CHAIRMAN said if foundrymen could get a sand on which they could rely for consistent results, they would be only too grateful. The foundry manager would welcome any experiments, or results of any research work, which would definitely help him in his work.

MR. WALKER said that the value of sand testing in actual foundries was shown by the fact that, during the past year or two, a considerable number of firms had installed sand-testing apparatus in their foundries and in the laboratories, and he had not yet heard of a single case where it had not saved its cost in a very short space of time even with the simple apparatus which they had at their disposal at present.

The CHAIRMAN agreed that money spent on sand-testing equipment was soon recovered in the foundry.

Improving Strength Properties

MR. F. E. STEELE said he had been much interested in Mr. Buchanan's figures, which they would be able to examine in detail when they were published. There were one or two matters on which he was not clear. He understood Mr. Buchanan to say that when the strength of the green sand was built up, they obtained better results. If he was wrong, he hoped Mr. Buchanan would correct him.

They had been led to believe that the more they could eliminate gas actually in the mould, the better it would be, yet he noticed that in some of the mixtures mentioned by the lecturer there was quite a large percentage of coal-dust. Rightly or wrongly, it was his belief that the addition of coal-dust in the surface of a mould tended to increase the difficulty of gas in the mould. Those having much work to carry out in green sand encountered difficulties not met with in dry-sand practice, *i.e.*, the excess of steam, and also an increased gas content. He asked Mr. Buchanan whether, when they increased the strength by the addition of clay, either in the natural sand or in the form of bentonite, they were not tending to run dangerously near the point when they would reduce the porosity of that sand to such an extent that they would increase the surface heat of the mould when cast, and get what they would call "spelching" or scabbing due to hot spots on the surface of the mould. As Mr. Roxburgh had said, they did definitely get those two forms of scabs.

He would like to ask Mr. Buchanan if he did not think that the design of the casting, changing rapidly from a thin to a thick section, very often was a cause of disturbance on the surface of the mould, thus tending to form a scab. In the running of a mould they very often found it essential to use a stronger sand just where the impinging of the metal occurred. Could he recommend that they should use a uniform sand throughout the mould to avoid that?

Change of Section and Scabbing

MR. BUCHANAN said there was no case of building up the strength of the green sand. It was actually in the mixture made from firebricks. It was proved there that a strong sand due to a strong clay gave a freedom from scabs, whereas when it was weakened, scabbing increased, and then, if they increased the strength again, it disappeared.

The amount of coal-dust used was, he believed, quite normal. He did not know whether the amount of gas evolved from coal was so much as was thought, because with 6 per cent. coal-dust, the gas, mostly volatile, was only 30 per cent. of that amount, so that it was probably not so important—certainly not so important as moisture content. The volatile was not produced till about 300 deg. C., whereas steam was formed at 100 deg. C.

. The increase in clay would probably increase the heat conductivity of the mould and might cause trouble on that score, but if a stronger bond was to be used to eliminate scabs they would of course be careful of the permeability. That was a point he tried to bring out.

With regard to a sudden change of section and design, where there were round curves and so on, especially if moisture was coming from a warm part of the mould and condensing on a cold part, change of section of that nature would tend to produce scabs locally, as he supposed they had often seen. As to the case of running where the metal was liable to impinge upon parts of the mould, it was desirable to increase the clay content for eliminating scabbing, but he believed plain sprigging was just as effective, and would probably lead to fewer troubles of another nature. The method of overcoming scabs would either be the use of clay to increase its strength up to the necessary level, or heavy sprigging about that part of the mould, or even shallow surface venting.

Influence of Backing Sand

MR. C. D. POLLARD said that when Mr. Buchanan indicated that he would refer to scabbing, he hoped that they would hear a reference to backing sand. As a foundryman, he was disappointed in not hearing such references more often by experts. He would ask Mr. Buchanan whether, in making up his tests for the specific purpose of producing scabs or otherwise, any backing sand was used, or whether the whole of the mould was made up of the facing sand which he was testing. If not, could he give an opinion on the influence of backing sand on the production of scabs on castings?

MR. BUCHANAN said the core was the only part which was used for the actual experiment. The top part had no bearing on it, as it did not come in contact with the surface examined. That core, moreover, was made entirely from the sand prepared for the purpose. There was no backing sand in the centre or any other part. Speaking from his own experience, he thought most backing sands were very similar to facing sand, except that they were probably not so well mixed. He had never known backing sands to be very much different from facing sand. For machine-moulding it was almost common now to use one class of sand throughout, unless specially sifted sand was wanted for a fine finish.

MR. POLLARD, pursuing his point further, said that in the vast majority of foundries backing sand was not controlled to anything like the extent that the facing sand was. Scabs were due probably to steam, or again to some interference with free venting, and surely the influence of backing sand must be detrimental if that backing sand was not conditioned like the facing sand? He would like to have an expert opinion on the influence of backing sand when it was not properly controlled.

MR. BUCHANAN replied that, regarding the formation of scabs, he had assumed for the purpose of his work that the depth of the mould actually influenced was less than $\frac{3}{8}$ in., which was well within the thickness of the facing sand used in that particular case. He could not see how the backing sand had any influence there, unless Mr. Pollard referred to pieces of coal or the like near the surface of the mould; these did cause trouble. There might also be lumps of clay, and if it was in such a condition anything might go wrong. As far as he knew, the scabs he had mentioned were caused under the facing sand layer, and were not affected by the backing sand.

The CHAIRMAN said that in green-sand practice, it was most important to vent the top part, and therefore he suggested that the backing sand was nearly as important.

Functions of a Mould Assembly

MR. WALKER agreed with Mr. Buchanan. The function of the mould box was to support the backing sand; the function of the backing sand was to support the facing sand, and the function of the facing sand was to support the surface of the mould, if this was made of other material than the facing sand. The properties of the backing sand were important in green-sand castings, but the larger the casting, especially in dry sand, the less important were the properties of the backing sand. In making very small green-sand steel castings the backing sand must be in good condition as it was not a great distance from the front to the back of the whole mould, but in a big mould the importance of the properties of the backing sand was often overrated.

Too much importance was also sometimes attached to permeability. In the discussion they had been speaking of green-sand and dry-sand castings in iron, and of green-sand and dry-sand castings in steel, all of different sizes. This was like speaking in different languages, and they could not answer all the queries by statements which would be of general application. In dry-sand steel practice, for example, he did not believe that the permeability of the actual face was important, in fact it was often very good practice to seal up the surface entirely so that no gases could escape one way or the other through the face.

Where Backing Sand is a Factor

MR. POLLARD said he was delighted to hear Mr. Walker say that he did not think the permeability of the facing sand really mattered. That rather bore out his (Mr. Pollard's) view that the backing sand was very important. In a thoroughly dry mould (he was speaking of steel), no doubt the backing sand was of minor importance, but in a foundry where they were making castings similar to those Mr. Walker had mentioned, and where the mould stood on the floor for probably two days or more, the moisture was liable to strike back. If they could not draw the steam away from just behind the facing sand, would poor backing sand have an influence? If the backing sand was in a bad condition (for instance, with a lot of silt in it), he thought it must have a detrimental effect on the surface of the castings.

MR. WALKER said that dry-sand moulds in a steel foundry should not be allowed to stand for two or three days, or sometimes even for two or three weeks, before casting. That was inviting the trouble which was often experienced, for the surface layers of the moulds absorbed water and their strength decreased rapidly. In this condition the surface of the mould was readily washed away and disintegrated by the steel, and this formed another way in which scabs could be obtained. The steel was liable to penetrate through the mould surface and a large excrescence would be left.

Slow Filling and Scabbing

The CHAIRMAN said there was still another way of getting scabs, and that was associated with the running of the mould. He cited a recent case in which the mould filled very slowly, with the result that the sides were scabbed. If a mould was run slowly it could pull in its top or side, and therefore the speed of running of a casting was a very important point too.

MR. BUCHANAN said that in any of the cases he referred to, the mould had been filled as quickly as possible, because there was no doubt if one left the sand unsupported by metal certain parts might draw down.

The CHAIRMAN asked Mr. Walker whether, in casting a flat plate, say 4 ft. or 5 ft. square, in green sand, he would be content just to ram up with $\frac{3}{4}$ in. or 1 in. of facing sand, and then use backing sand, and not artificially vent the mould at all.

Steam Production Contrasted

MR. WALKER assumed that the plate in question was a cast-iron plate and, that being so, said he had not sufficient experience of such plates to dogmatise.

The CHAIRMAN thought that the backing sand was important in such green-sand castings.

MR. WALKER said that the volume of steam developed from the water in green sand greatly exceeded the volume of gases developed from organic compounds which might be present in the sand. One volume of water would probably give an average of 2,000 volumes of steam, and provision should be made in green-sand casting for this steam to escape as readily as possible.

The CHAIRMAN agreed that on dry-sand castings it was not so important.

MR. WALKER pointed out that, in dried moulds, the amount of water present should be negligible. It could only be present in quantity if the drying had been inefficiently carried out, or if the mould had been allowed to stand after drying.

Green-Sand Moulds and Backing Sand

MR. STEELE thought he could confirm the remarks of Mr. Pollard and Mr. Roxburgh. To sum up, they were all pretty well agreed that scabbing took place more in green-sand moulding than any other kind, and the condition of the backing sand in a green-sand mould was definitely a vital point. It was possible that backing sand was prepared by hand mixing. By digging into it and separating it, one could find patches where the water had clotted it together, and very often some of the difficulties could be ascribed to the fact that that clot of wet sand was near the surface of the job and had created a volume of steam which had released itself during casting. That did not apply in dry-sand moulding, but it was essential to control the backing sand in green-sand moulding, in iron, more carefully than in any other kind of moulding.

MR. WALKER said that in the foundry with which he was connected, it was found necessary, when making some types of small repetition steel castings in green sand, to mill the backing sand and so put it in a good condition.

"Blotting Pad" Practice

MR. BUCHANAN said he would not like it to be thought that he had given any impression that the backing sand was to be neglected, or that, for instance, green sand should not be vented. He recalled making some plates of the order of 4 ft. square, in which the facing sand was first put on, and then a layer of dry dust, the material generally found about a dry-sand floor, was incorporated, and the backing sand placed behind that; that method produced castings which were otherwise very difficult to make. It amounted to inserting a "blotting pad" behind the facing sand to absorb the steam.

Another point which should not be overlooked was that, with small green-sand work, if the metal was run as fast as it should be run, it filled the mould and probably solidified before steam was formed at any depth more than, say, $\frac{1}{4}$ in., so that in some cases outside venting was not so important as might be supposed. Although there were certainly large volumes of steam and flame emanating from green-sand castings, it did not mean that if the vents were stopped up it would necessarily form an equivalent number of holes in the casting.

Vote of Thanks

MR. R. D. LAWRIE, in proposing a vote of thanks, said the author, during his association with the Institute, had dealt with a very wide range of subjects, from cupola practice to sand treating and practical moulding. He was very pleased to be able to move a vote of thanks for his excellent Paper, which, as Mr. Walker remarked, would take some time to assimilate; but he had no doubt that, when the figures were set down in print, they would find some real commonsense in what Mr. Buchanan had put before them.

A Useful Summary

MR. W. H. SALMON, in seconding, said the Paper had been extremely interesting because Mr. Buchanan, in his usual style, had set out to compare the results of laboratory sand tests with the practical side of foundry work. He had

(*Concluded on page* 408.)

Shearing of Malleable Iron Gates*

By S. D. MARTIN

The five most prominent methods of gate removal from malleable iron castings are snubbing, grinding, shearing, milling, or broaching. The first three mentioned are the most satisfactory from a manufacturing standpoint. Milling and broaching produce a very satisfactory job, but are slow and expensive. Shearing is considered the most practical and economical.

Snubbing.—Castings made on a conveyor system will occasionally break back into the shrink bob when they are dumped at the shake-out. It is advisable and economical to snub this excessive metal off before the regular shear or grind operation occurs. This means that excessive grinding cost will be eliminated, broken shear knives kept at a minimum, and also that the excess metal snubbed off can be saved and remelted.

Grinding.—Numerous fixtures have been designed to assist in grinding small castings which are difficult to hold. However, in the majority of cases where it is possible to hold the casting with one hand, the leverage stick is the only tool used. This stick can also act as a holding device, by shaping it to fit the contour of the casting. The leverage stick appears to be a very crude piece of equipment, but it is hard to improve on when used by a skilled operator. On many jobs it is possible to increase metal removal 50 per cent. by the use of this stick.

Grinding is a very common method of removing gates, fins and partings that do not lend themselves to shearing. In many cases, this is the only method that can economically be used. Since shearing has more limitations than grinding, we find that in many cases we must process by means of grinding. However, at all times, it is advisable to reduce the amount of grinding work by the use of chipping fixtures, burring tools, or special shear dies.

Shearing

A casting and its gates must meet the following requirements to be adapted to shearing:—

(1) The locating points must be positive in relation to the gate. The most ideal locating points are at straight flat surfaces, as close to the gate as possible, and free from extensive warpage, parting lines, or fins.

(2) A casting should be strong enough to withstand shear stress at the gate, without deforming.

(3) The shear point of the gate must be in a straight line with the travel of the shear knife. Shear action occurs in a straight line from the point of the shear knife to the shear point of the anvil. It is impossible to produce a curve or taper in the direction of the shear. However, it is practical to shear along an irregular contour by shaping the cutting edge of the knife to conform with the contour of the casting.

(4) Gates must be free of defective iron. An operator may distinguish hardness, and shrunken or spongy iron at the gate. Hardness is determined by the snap with which the gates break off. Shrunken or spongy iron tears out or breaks in at the gate when sheared. It is found that decarburised iron has a tendency to cause the sheared gates to stick to the shear knife.

(5) Gates should be properly designed for shearing. Fig. 1 (A, B, C and D) illustrate this. The top of the gate should be flush with the castings as shown in Fig. 1 (A, B, C) This gives the knife a good starting surface and prevents it from running. When the top of the gate is not flush with the casting and the locating points are on the same sides as the gate, as in Fig. 1 (E), the knife, if a little dull, will push the casting away from the stops, or perhaps start at an angle.

(6) Fig. 1 (B, C, D) illustrate good types of gates to use whenever possible. By keeping the lower edge of the gate away from the casting, or the anvil, the corner of the casting is strengthened and is less apt to break in.

(7) When it is necessary to shear a gate, as shown in Fig. 1 (D), due to the weakness of the rib (*a*) the gate should form an angle of 90 deg. with the casting so as to provide a good starting point for the shear knife. The shear knife will slide along the 2-deg. clearance angle giving a clean shear, with less possibility of hitting the top of the casting. Castings of the type shown in Fig. 1 (C), having a rib (*b*) strong enough to support the shear stress, do not require a shearing anvil,

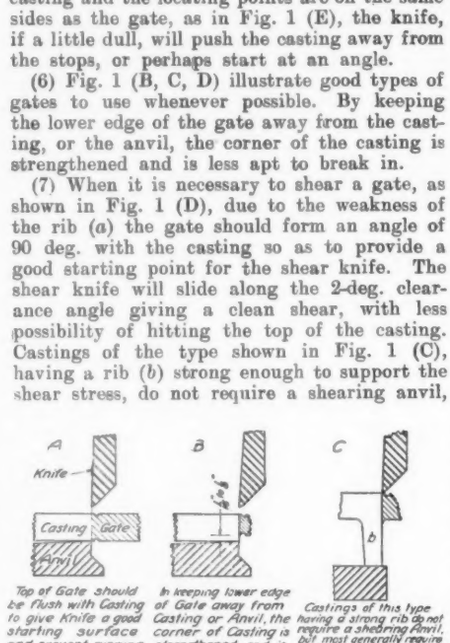

A
Knife
Casting
Gate
Anvil
Top of Gate should be flush with Casting to give Knife a good starting surface and prevent running
B
In keeping lower edge of Gate away from Casting or Anvil, the corner of Casting is strengthened and is less apt to break off
C
b
Castings of this type having a strong rib do not require a shearing Anvil, but most generally require a Clamping Device to prevent Casting from tipping.
D
2°
90°
When rib is too weak to support shearing stress, shear as shown above
E
Locating Point
When top of Gate is not flush with Casting and Locating Points are on same side as Gate, the Knife, if a little dull, will push Casting away from Stops or cause Knife to start at an angle.

FIG. 1.—TYPICAL GATES FOR SHEARING.

but most generally require a clamping device to keep the casting from tipping.

(8) Production of castings must be sufficient to warrant die expenditure.

(9) A 50-ton shear machine is recommended for use in shearing up to 1 sq. in. of metal. As the cross-sectional area of the gate increases, the capacity of the machine should also be increased.

Construction of Dies

The essential parts of a shear die are:—(1) A support or shear anvil for the casting to rest upon; (2) stops which locate the casting in the shear position; (3) a holding device to prevent the casting from shifting out of location during the shearing operation, and (4) a shear knife for gate removal. These parts are combined into various die designs to suit the characteristics of the castings for which they are intended.

Shearing anvils are used to support the castings at the point of shear. When these anvils are set up properly against the knife they will prevent the gate from breaking into the casting, and also the casting from tipping.

The top side of the anvil should taper back from the shear edge so that there is at least 2 deg. clearance between the anvil and the castings. The purpose of this is to ensure a contact of the casting on the anvil at the point of shear.

The front side of the anvil should have a 2 deg. clearance for rake. The shear knife should pass the shear point of the anvil at least ¼ in. so the gate will cut cleanly. This also aids in wiping the gates off of the knife when they have a tendency to stick. Anvils have a tendency to embed into the die holder; therefore they should cover ample area to reduce this wear. A lip starting about ½ in. down from the shear edge, on a 45 deg. angle and extending towards the chip hole, supports the front side of the anvil and prevents the lever action which is set up during shearing. If this lip is not included in the die, the shear stress causes the anvil to tip, embedding the front side more than the rear, and is responsible for the loosening and breaking of the screws holding the anvil.

Anvils should be made of a high-grade tool steel and hardened to 60 Rockwell. The following composition has been found satisfactory:—C, 0.66 to 0.75; Si, 0.20 to 0.35; Mn, 0.10 to 0.20; S, 0.025 max.; P, 0.025 max., and V, 0.15 to 0.25 per cent.

* Extracted from a Paper presented to the Cincinnati Convention of the American Foundrymen's Association. The author is Better Methods Engineer, Saginaw Malleable Iron Division, General Motors Corp.

Foundry Sands

(*Concluded from page 407.*)

shown there was no relation between his expansion curves on the sand specimens heated slowly to temperatures of about 900 deg. C. and "scabbing," and had suggested a formula which indicated that scabbing was caused by low dry strength, low permeability and high moisture content. While one felt that these factors were more important than expansion or contraction under slow rates of heating, there were three other important factors: (*a*) whether the mould was green or dried, (*b*) speed of casting, and (*c*) rate of heating the test-piece. Probably a slow rate of heating did not indicate the tendency to scab, because, after all, the rate of heating of the thin layer of sand in a mould was extremely rapid, so that a test on the lines of the "spalling test" used for fired refractories might prove more useful. It had been shown by the First Report of the Moulding Materials Sub-Committee that when dried sand moulds were exposed to the atmosphere after allowing them to become cold, they picked up moisture on the surface, with consequent loss of dry strength, conditions very liable to produce scabbing. It was known that green sand, with its lower strength and higher moisture content (but higher permeability) than dry sand, was more liable to scab, and special methods of gating and running were necessary to cast thin plates. They made a number of special cast steel plates, up to 8 ft. long by 4 ft. wide, in thicknesses from ½ to 1 in.—a difficult proposition in green sand, but very much simplified when dry-sand moulds and high casting rates were employed. Smaller cast steel plates 4 ft. by 3 ft. wide were made in green sand. An experiment had shown that a dry-sand mould left two days before casting scabbed, but a green-sand mould of more permeable sand, left ten days before casting to allow the surface of the mould to attain atmospheric humidity (about ½ per cent. H_2O) did not scab. It was, of course, desirable to cast green-sand moulds on the day they were made, and dry-sand moulds were cast before they became cold.

The resolution was carried with heartiness, and Mr. Buchanan briefly replied.

Engineering Wages Increased

An agreement in settlement of the engineering unions' claims for wage increases to well over a million workers was announced on May 10. This agreement, which recommends the unions to accept an increase in the national bonus of 2s. a week to all male workers, was reached after a five-hour talk in London between the unions and the Engineering and Allied Employers' National Federation. The increase is to apply as from the commencement of the pay period starting in the week beginning June 5.

Training the Young Foundryman*

By W. GLADWELL

It is felt that before any attempt is made to discuss the syllabus of training, two important and controversial subjects should first be tackled. These are: who is to be the student, and what are his reasons for commencing the training? It is proposed to approach these subjects in the reverse order, and it should be mentioned that the following remarks are not so much personal (a good proportion are), but are more in the nature of a review of expressions of opinion made by seniors, both in the foundry and at technical meetings.

It may be assumed that students taking the foundry classes may be divided into two main groups. These are:—(1) Those who have no wish to accept responsibility, and are taking advantage of the facilities offered with a view to earning the title of being "the best man on the floor"; and (2) those who desire to improve their position in the industry.

Training for Craftsmen

With reference to the first type of student, it is common to hear a certain type of foundryman with a lifetime of practical experience, but no technical knowledge, say "One cannot learn moulding from reading, or in a college," and the writer accepts this view. The place to learn moulding is the foundry floor, but where he goes wrong is in not realising that a combination of really good moulding technique, learnt on the floor of a good-class foundry, coupled with a sound theoretical knowledge, makes a good moulder into an even better one, because practical experience only indicates *what* to do, but technical knowledge tells *why* to do it.

With the growth of mechanisation, the type of student who wishes to excel as a moulder appears to be in the minority, as it is a fairly safe assumption that students of this class will be drawn from the ranks of the foundry whose work does not readily lend itself to mass-production. In order that there shall be no misinterpretation, it should be made clear that it is not meant that all students from this type of foundry will not wish to accept the responsibility of a higher position, but rather that one cannot expect a machine moulder to attend classes on how to operate his machine, or how to make condenser shells or cylinders he probably will never see.

Training for the Executive

With reference to the student who wishes to improve his position in the industry, his motives will be different. The old school will probably insist that it is for one of two reasons: either he is too big for his boots, or he does not like hard work. A personal belief is that his main incentive is interest in his job. Students of this type will be drawn from all sorts of foundries and may include men who are not actually foundrymen. It is assumed they represent the majority and it is intended to deal mainly with them.

Should anyone query the foregoing on the grounds that a boy just leaving school does not reason out his motives in going to classes, it has been personal experience, during the past few years, to notice the vast difference in age between foundry students and other students. The foundry students are, on an average, four or five years older, in their respective grades, than other engineering students, on whom more pressure seems to be applied in the earlier stages of their jobs. This fact does cause one to think that, at the present time, the foundry student goes to his classes after weighing the "pros and cons," and not through parental discipline.

Character of the Entrant

It is fairly common practice to compare the youngsters in the foundry very unfavourably with those in other departments of an engineering works. It has been said, when a boy leaves school and prepares to enter an engineering works, the first place he tries to enter—or his parents try for him—is the drawing office, failing that the patternshop, or machine shop and assembly departments, while the foundry is right at the bottom of the list.

If this statement be accepted, it appears that the lads who enter the foundry will be those whom the other departments do not want. Without wishing to labour this point too much, it is appropriate to mention a recent conversation with a patternmaker. Discussing a mutual friend who is in a foundry, the patternmaker observed: "You know, he is really too good to be in a foundry." When the author suggested that it was in the foundry that the jobs were actually made, and that this was where good men were required, his only reaction was to find such remarks too humorous to require serious consideration.

Founding has become a scientific industry, and trial and error methods are fast dying out. Mixtures are no longer made up by looking at the fracture, but by analysis; sand is checked, not by the feel of it, but by moisture, permeability and strength tests, etc. One of the next important moves required is to take steps to remove the old label of being dirty.

Because a man works in sand all day, it constitutes no reason why he should take home a goodly portion of it about his person. The author has often suggested to foundry executives that some provision should be made for the foundryman to clean himself before going home, but he has always been told that the man who works in a foundry would not appreciate any such facility, but within the last year there is definite proof that this is the wrong attitude to take.

Washing Facilities

A foundry within 20 miles of Lincoln has in one corner white hand-basins surrounded by white tiles, for the use of the men. When they were first erected, the foreman insisted that the basins be kept clean, and now special supervision is unnecessary, their appearance being a shop concern.

Surely it is not too much to ask for some form of washing accommodation? If nowadays miners can leave the pits clean, is it too much to ask for similar facilities for the men in the foundry, and in the case of the younger ones to see to it that they take advantage of it?

Should anyone be thinking the author has strayed from his original subject, it is suggested that progress along such lines with improved working conditions would do much to alter the views quoted, and would tend to attract a better type of lad to the foundry. More than that, it would increase the self-respect of the lad at present in the foundry, who is by no means as black as he is painted—or looks. With such an increase in self-respect, the natural conclusion can be drawn that an increase in interest in the job, and a desire to get more fully acquainted with it, would arise much earlier than is the case at present. Moreover, a greater effort than at present would be made by the heads of firms to get these youngsters to go to evening classes at the same time as other youngsters on the firm.

With this in mind, it can be postulated that the raw material for foundry classes would be as young and as intelligent as students for any other branch of engineering. The students for foundry classes would be young lads of average mental ability, and, owing to the growth of mechanisation, the courses will need to be more theoretical and scientific than practical. This brings the subject to the most important part of all, the syllabus for training in foundry practice and science.

In attempting to draw up the following syllabus, an endeavour has been made to keep two objects in mind:—(1) To remember that the course is to train men for the foundry, and not turn foundry lads into metallurgists or cost accountants. (2) To remember the old adage that all work and no play makes Jack a dull boy.

Syllabus for Training Young Foundrymen

1st Year.—Practical Mathematics (Grade 1).

Engineering Drawing (Elementary). The lecturer would be requested to concentrate more on drawing methods and practice than the usual syllabus for this subject, *i.e.*, rivets, types of threads, etc.

2nd Year.—The same subjects, but slightly advanced.

3rd Year.—Engineering Drawing (Revision and Practice). Chemistry (Elementary). More in the nature of a revision of elementary school work, *i.e.*, the elements and their chemical symbols. Foundry Practice, Grade I (see below).

4th Year.—Metallurgy of Cast Iron. Elementary and preferably given by a works metallurgist. Foundry Practice (Grade II).

5th Year.—Metallurgy of Cast Iron (continued), including a review of non-ferrous alloys. Foundry Practice (Grade III).

Foundry Practice.—Grade I

Sand, its properties, physical and chemical.
The values of coal-dust and blackings.
Loose patterns, permanent oddsides, plate-work and their values.
Elementary review of moulding methods.
Green sand, dry sand and loam.
Cores and their uses, coremaking and methods of supporting cores in moulds.
Cupola construction and operation.
Cast iron, shrinkage, contraction, warping and camber.
Application of practical mathematics to foundry calculations.

Foundry Practice.—Grade II

Sand testing, moisture, permeability and strength.
Mixtures for green and dry sand.
Laws of gating.
Types of ingates.
Application of risers.
Moulding machines, types and their uses.
Melting furnaces and their uses.
Practical application of engineering drawing in layout of jobs.

Foundry Practice.—Grade III

Loam moulding, mixture for loam, layout of jobs, tackle required, practice designing strickles from drawing.
Foundry costing and layout of foundry.
Estimating from drawing.
Review of non-ferrous foundry practice.
Revision of Grades I and II.

In conclusion, if these views on the training of foundry apprentices clash with accepted ones, the author would very much like to know the reasons for disagreement.

DISCUSSION

The CHAIRMAN (Mr. G. L. Harbach) said that in his experience also the foundry student was, on the average, several years older than the engineering student of a comparable stage in technical training. This he considered due in part to the fact that foundry students attended classes from personal consideration of their own

* Short Paper read to the Lincoln Section of the Institute of British Foundrymen.

welfare at an age when they realised the importance of technical training, whilst engineering students started their classes automatically when they started work. Another point was that very few foundry students had any opportunity for day study, whilst it was compulsory in most other branches of industry in Lincoln and Newark. (An inquiry put to the meeting showed that, out of nine foundry students present, none had the opportunity to take day classes, but three out of four patternshop students present were attending day classes.) Lecturers to foundry students should be capable of close co-operation with the students on day-to-day problems, and their aim should be to build bridges between the various subjects and foundry work rather than endeavour to turn them into draughtsmen or metallurgists. He also said improved conditions would increase self-respect and attract a better type of boy into the foundry.

MR. E. R. WALTER (Principal, Lincoln Technical College, and member of the Education Sub-Committee) agreed in the main with the points raised in the Paper. There was no doubt conditions were definitely improving both from the viewpoints of practice and technical training. He agreed the machine drawing was often a difficult subject for the foundry student, and he suggested that the drawing of nuts and bolts could be avoided and that layout should be brought in from the start. It was his opinion that the teacher should be associated with the foundry—the selection of such a man was not an easy task—and the instruction as far as possible should be made to relate to foundry work.

MR. H. E. CAVILL agreed on the points brought up regarding machine drawing and felt the foundries themselves were to blame by not having day courses at schools for foundry apprentices. Ultimately, the present policy would result in a shortage of skilled men.

MR. F. DUNLEAVY suggested the creation of foundry classes for foundry students and the elimination of classes to include patternshop apprentices and young draughtsmen, for this caused the lecturer to hold back the foundry instruction to suit the non-foundry students. Moreover, foundry examinations seemed to favour the students who were familiar with machine drawing in their daily work, thus making it easier for non-foundry students than foundry students to pass the foundry examinations.

MR. GLADWELL briefly replied and thanked the members for the interest shown by the points raised in the discussion.

The meeting closed after members of Council had judged the moulds made by the foundry students and selected the first and second prize winners.

Iron and Steel Production

The British Iron and Steel Federation reports that there were 100 furnaces in blast at the end of April in the United Kingdom, compared with 95 furnaces at the end of March, five furnaces having resumed operations during the month. The production of pig-iron in April, at 608,900 tons, included 103,500 tons of hematite, 392,600 tons of basic, 92,400 tons of foundry and 12,900 tons of forge pig-iron. Output in March last was 603,600 tons, and in April, 1938, 661,000 tons. Steel operations continued to expand in April, and output of steel ingots and castings was 1,058,200 tons, compared with 1,170,900 tons in March last and 938,600 tons in April, 1938. The number of open-hearth furnaces working rose from 326 to 332 and further capacity is available if required. Allowing for the Easter holiday and for the shorter calendar month, there were three fewer working days in April compared to March. The average daily rate of output therefore shows an increase over March.

Production of Bronze Pressure Castings

Discussing the production of bronze pressure castings in a Paper read before the Cincinnati Convention of the American Foundrymen's Association, MR. D. FRANK O'CONNOR dealt in detail with the manufacture of cores, moulding, moulding sand and melting. Extracts from the Paper are appended.

Cores

Cores are made by hand and machine. Local sands are used in making core mixtures. Oil is used for binder and weighed with sand for making up the mixtures. The sand is mulled to the proper consistency and contains not more than 3 to 4 per cent. moisture. Grain fineness of 160 is maintained to produce a smooth finish and good permeability, allowing gases to pass off freely.

Most of these cores are blown on machines. A uniform core requires proper venting and a little experience will produce sound cores, hard enough to resist metal penetration. Cores must be not rammed too hard, but only hard enough to hold their shape. They must be vented properly so that the molten metal will lay against them without blows or cutting in. This is important in the production of sound pressure castings, inasmuch as the core must give against metal pressure, as also must the moulding sand.

Melting

Metal charges are made up of 40 to 60 per cent. ingots and the balance in gates, castings and borings. Open-flame type and crucible furnaces are used. In an open-flame furnace, where the flame is in direct contact with the metal, a proper metal zone is important. Proper combustion to prevent the absorption of gases or impurities is essential. The furnace should be preheated thoroughly before metal is charged, after which the metal must be melted rapidly and not over-heated to get maximum physical properties. This practice is applicable to most of the bronze alloys used for pressure castings. A few minutes before tapping, low melting-point metals are added and thoroughly mixed in the bath of metal. The temperature of the metal is recorded, and heated until 25 to 50 deg. C. above the pouring temperature. Heats of 700 to 1,000 lbs. are melted in this type of furnace. To ensure proper melting conditions throughout the melt, the flame is kept slightly on the oxidising side, and careful maintenance of the melting zone and the burners which regulate the combustion is necessary.

Steel ladles of 150 lbs. capacity, lined with fire sand and preheated to white heat, are used for pouring. A few ounces of 10 per cent. phosphor-copper is placed in the ladle just before pouring, and when filled with metal, charcoal is placed on top to prevent further oxidation. This remains on the metal until it is poured.

Pouring

Pyrometers are used in recording the melting and pouring temperatures. The pouring temperature of any casting depends on the design, gating, size and type of casting, and the alloy to be poured. The castings are submitted to a severe air test under water, and to get maximum physical properties and pressure tightness with the majority of the bronze mixtures, the practice is to pour the metal for light and medium size castings between 1,175 and 1,230 deg. C., with sufficient gate and head for a uniform rate of solidification. Heavier castings are poured at lower temperatures, but not under 1,150 deg. C.

To aid in the pouring, a strainer core is set in the mould at the base of the sprue, which prevents the high temperature metal from cutting into the moulding sand. The sprue is kept full while pouring and the metal enters the cavities under pressure rather than running in by gravity. The pouring temperature is taken at the moulding floor and the metal is stirred well before pouring. The average drop in temperature from the first to the last mould is 20 deg. C. on small and medium size castings. The metal is covered with charcoal throughout the pour, preventing excess oxidation. Moulds are poured horizontal.

It has been found that sand control is necessary to produce castings with good surface finish and free from pit or gas holes under the surface. The practice is to have the moisture content as low as possible, with permeability and strength high. The sand should be at room temperature or warmer, if possible, but not above 90 deg. Fah., because pouring in warm sand produces a greater yield of good castings. This prevents the building-up of great pressures within the mould and allows the gases to escape freely. The physical properties of the sand used are:—Moisture, 4.5 to 5.5 per cent.; permeability, 18 to 20; and strength, 5 to 6 lbs. per sq. in.

Excess jar ramming, hand ramming or squeezing lowers permeability, preventing the metal from flowing properly against the sand. This causes blows, scabs and intercrystalline porosity. As each pattern presents its own problem in ramming and squeezing, the machines are equipped with pressure gauges and care is taken to see that jobs are assigned to the machine with proper flask equipment. The flask, especially the cope half, must be deep enough to prevent a hard squeeze. Where jar ramming is used, the centre of the mould is inclined to be the hardest, and to equalise the mould hardness the sand is often spread to the outer edge of the flask and built up to allow a greater pressure from the squeeze. Experience soon develops the proper mould hardness for a given job. A mould should not be rammed any harder than is necessary to resist metal pressure and assure perfect casting form.

It is a simple matter to control pouring, pouring temperature, pouring range, and the moisture of the moulding sand, which are the major causes of a great percentage of porous castings. The practices are not difficult to set up; the important thing is to maintain them. With these practices, losses on pressure castings due to porosity are less than ½ per cent.

Book Review

Stock Exchanges' Ten-Year Record. Published by Fredc. C. Mathieson & Sons, 16, Copthall Avenue, London, E.C.2. Price 20s. 6d. post free.

This is the 31st year of issue of this well-known and much-appreciated guide. It is not a very cheerful edition, as the international situation caused quite an illogical lowering of price levels, although the majority of companies were working sufficiently near to capacity to maintain the previous year's dividend, whilst acceleration of the rearmament programme and other legislation promised a high level of general industrial activity. To those who interest themselves in the share markets, this book must be particularly helpful in getting a proper perspective of values.

MR. CHARLES MCDERMID, who for many years has been Secretary of the Institution of Mining and Metallurgy and of the Institution of Mining Engineers, is shortly to retire, and the Councils of both Institutions have appointed their respective Assistant Secretaries, Mr. William John Felton and Mr. John McDermid, as secretaries designate to take up their full duties at the end of May and the end of June respectively.

Light Castings need a *Fluid* Iron!

A free-running fluid iron is essential to produce clean, sharply-moulded light castings such as Rainwater pipes, Drain pipes, Builders' Hardware, Baths, Stoves, Gas and Electric Fires, etc. The relatively high phosphorus content of Rixon's (W'bro'.) No. 3 Foundry Iron ensures the necessary fluidity for this class of work.

Rixon's (W'bro'.) Irons are produced in two modern furnaces solely for the open market.

Fluidity Test

The illustration shows a typical spiral cast with a mixture containing Rixon's Iron. The feed to the spiral was only $\frac{3}{8}$-in. diameter.

ANALYSIS

	Per Cent
Silicon	3.29
Sulphur	0.025
Phosphorus	1.69
Manganese	0.34
Graphitic Carbon	3.52
Combined Carbon	0.12
Total Carbon	3.64

THE STANTON IRONWORKS COMPANY LIMITED
NEAR NOTTINGHAM

The largest producers of Pig Iron (for Sale) in Great Britain

RIXON'S (W'BRO') No. 3 Foundry Iron

The Week's News in Brief

Trade Talk

LEAD PIPES, LIMITED, have opened an office in London at 32, Queen Victoria Street, E.C.4.

LITHGOWS, LIMITED, Port Glasgow, have received an order for two vessels, each of about 5,000 tons gross, from the Asiatic Steam Navigation Company, Limited, London.

ROBERT DEMPSTER & SONS, LIMITED, of Elland, Yorks, gas engineers and ironfounders, have successfully tendered for the provision of purifiers at the gasworks of Hamilton Town Council.

SWAN, HUNTER & WIGHAM RICHARDSON, LIMITED, Wallsend, have received an order from the British India Steam Navigation Company, Limited, for a cargo passenger ship of 8,300 gross tons.

THE NUMBER OF WORKPEOPLE covered by collective agreements providing for annual paid holidays is estimated at about 4,000,000, states a report on holidays-with-pay issued by the Ministry of Labour.

ANOTHER BLAST FURNACE has been blown-in at Gartsherrie by Wm. Baird & Company, Limited, producing basic pig. There are now 11 furnaces operating in Scotland, five of which are on foundry iron.

THE BRITISH ALUMINIUM COMPANY, LIMITED, have opened a branch office and warehouse at Abbey Buildings, Middle Abbey Street, Dublin (Telephone No. : Dublin 22966), under the management of Mr. D. E. Cottrell.

INTERNATIONAL COMBUSTION, LIMITED, have recently received orders for four Lopulco pulverised fuel-fired boilers; seven Lopulco "L" stoker-fired boilers; also numerous orders for their "L" stokers, together with a coal-handling plant, an ash conveyor and a handling and screening plant.

THE LANARKSHIRE STEEL COMPANY, LIMITED, Motherwell, celebrates its jubilee this year. The founders intended to erect the plant at Carmyle, near Glasgow, but accepted an offer of a site by Lord Hamilton of Dalziel. A controlling interest in the company was acquired by Colvilles, Limited, in 1936.

THE BRUSH ELECTRICAL ENGINEERING COMPANY, LIMITED, Loughborough, has received an order for a 30,000-kw. Brush-Ljungstrom turbo-generator from the West Midlands Joint Electricity Authority, for installation at their Wolverhampton generating station. The value of the order is approximately £110,000.

A TEMPORARY SETTLEMENT was reached last week at the Tubal works of Shanks & Company, Limited, Barrhead, where a three-weeks' stoppage by 27 brassmoulders threatened to involve members of other trade unions. The company has agreed that two skilled plate moulders should operate a new electric moulding machine that has been installed, instead of one skilled operator and a labourer. This temporary agreement will operate for a month.

SIR KINGSLEY WOOD, Secretary of State for Air, visited the works of the Northern Aluminium Company, Limited, at Banbury, this week. He inspected the re-melt department, rolling mills and extrusion section, and was interested in a model showing the company's camouflage schemes for the factory in case of emergency. He congratulated the aluminium industry on the considerable contribution it had made to air defence. The Air Minister was shown round the works by Mr. F. S. Mitman (managing director), Mr. H. F. James (director) and Mr. E. L. Ashley (works manager).

DORMAN, LONG & COMPANY are blowing in at their Cleveland Works a large new mechanically-charged blast furnace for the production of basic iron for steelmaking purposes. This furnace is immediately adjacent to and of a capacity and type similar to that of the two modern furnaces recently reconstructed at these works. It is fitted with the latest type of mechanical charging, with automatic blast, temperature control, and a large new modern turbo blower. The furnace will produce 2,750 tons of basic iron per week. It will be fully equipped with new hot-blast stoves, ironstone calcining kilns, and bunkers for raw materals. Coke will be fed by belt conveyor direct from the new coke-oven plant recently installed. Iron will be delivered to the steel plant in molten condition in 45-ton hot-metal ladles. The gas cleaning plant is also being extended to deal with the gas from this furnace, which will be washed and used for steam-raising generally and in the soaking pits and reheating furnaces at the mills.

Personal

MR. J. C. FARRANT, of International Combustion, Limited, left on May 9 for a trip to the Near East.

MR. J. SINCLAIR KERR, director of the Lancashire Steel Corporation, Limited, has been elected a Member of Council of the Iron and Steel Institute.

MR. JOHN GIBB, who has been foreman of the heavy iron foundry of Glenfield & Kennedy, Limited, Kilmarnock, for the past 33 years, has retired after 53 years' service with the firm. Mr. Henry Gardner (works manager), at a gathering of foremen and staff last Thursday, made the presentation to Mr. Gibb of a gold watch, suitably inscribed, together with a mantel timepiece.

Wills

JONES, JOHN J., of Loughborough, head of John Jones & Sons, Limited, ironfounders £17,190

MOSS, A. H., managing director of Ernest Newell & Company, Limited, colliery engineers and ironfounders, Misterton, Doncaster £9,658

BROWNRIGG, Rear-Admiral Sir Douglas E. R., deputy chairman of the Fairfield Shipbuilding & Engineering Company, Limited, Govan £18,516

Obituary

MR. KENNETH D. MACKENZIE, a prominent figure in Glasgow and West of Scotland steel circles for a long period, and a director of Fred. Braby & Company, Limited, for 25 years, died on May 8. For the same number of years he was general manager of the firm's Eclipse Works, Glasgow.

LIEUTENANT CHURRUCA Y ZUBIRIA, of the well-known Bilbao family, died at Toledo on May 2. He had a very distinguished military career in the forces of General Franco, and was honoured with a military funeral, at which General Alonso Vega delivered a funeral oration and invested the deceased with the Military Medal. Senor Oriol, the governor of Bilbao, at the same time invested the deceased with the Medalla de Oro de Bilbao.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Blake's Foundry, Limited.—Capital, £2,000. Permanent governing director: W. H. Blake, 386, Whirlowdale Road, Sheffield.

Noncoralium, Limited, 38/9, Boswell Street, London, W.C.2.—Capital, £5,000. Ironfounders, etc. Directors: W. B. King and A. W. MacIlwaine.

Vis Construction & Development Company, Limited, Lep Wharves, Corney Road, Chiswick, London, W.4.—Capital, £500. Engineers and ironfounders, etc. Directors: F. C. Scott and H. H. G. Boal.

Warman Bros., Limited.—Capital, £1,000. Manufacturers of sandblasting equipment and machinery, etc. Directors: F. C. J. Nurcombe, Merrow Down, The Common, Kings Langley, Herts; L. B. Childe and J. Warman.

Zinc Development Association.—To acquire the assets, liabilities and business of the Zinc Development Association, Limited, and to promote increase in the consumption of zinc, etc. Subscribers: Imperial Smelting Corporation, Limited, London Zinc Mills, Limited, National Smelting Company, Limited, Electrolytic Zinc Company of Australia, Limited, Burma Corporation, Limited, Trepca Mines, Limited, and the Amalgamated Metal Corporation, Limited.

FIRTH-VICKERS STAINLESS STEELS, LIMITED, are exhibiting in the "Hall of Metals" in the British Government Pavilion at the New York World's Fair. The exhibit epitomises in a striking and graphical way the history of stainless steel.

Company Reports

Samuel Osborn & Company, Limited.—Interim dividend of 2½ per cent.

Atlas Steel Foundry & Engineering Company, Limited.—Interim dividend of 15 per cent.

Mason & Burns, Limited.—Dividend on the ordinary shares for the year ended March 31 last of 7½ per cent.

Ransomes & Rapier, Limited.—Profit for 1938, £26,282; brought in, £2,981; available after depreciation, interest on debentures and interim dividend of 2½ per cent., free of tax, on the ordinary shares, £22,638; dividend of 6 per cent. on the preference shares, £630; dividend of 5 per cent. on the ordinary shares, making 7½ per cent., tax free, for the year, £13,250; to general reserve, £5,000; carried forward, £3,758.

Stewarts and Lloyds, Limited.—Profit for 1938, including the results of subsidiary companies only to the extent to which dividends have been or are to be received, £1,931,234; brought in, £170,159; to reserve for income tax and N.D.C., £600,000; stock reserve, £75,000; reserve for maintenance and development of export trade, £500,000; employees' benefit reserve, £50,000; dividends on the cumulative preference stocks, £107,300; dividend of 12½ per cent. on the deferred stock and the liaison deferred shares, £589,549; carried forward, £179,544.

Contracts Open

Bideford, May 31.—Supply and erection of two gas-suction engines, two horizontal single-cylinder cold-starting type heavy-oil engines, each of sufficient power to drive by belting or flexible coupling, existing horizontal three-throw ram pumps working 14,000 galls. per hr., against a head of 300 ft., including suction and friction, for the Town Council. The Borough Surveyor, Town Hall Buildings, Bideford.

Neston, May 23.—Supply and erection of an electrically-driven automatic pumping plant, for the Urban District Council. Mr. F. R. Poole, clerk. Council Offices, Town Hall, Neston, Wirral. (Fee £1 1s., returnable.)

Port Kembla, June 26.—Supply and erection of two 20-ton electrically-driven, four-motor level luffing portal jib cranes, for the Department of Works and Local Government, New South Wales. The Agent-General for New South Wales, 125, Strand, London, W.C.2. (Fee 10s., non-returnable.)

Ryde (I.O.W.), May 24.—2,760 yds. of 12-in. dia. cast-iron or spun pipes and specials, for the Town Council. Mr. B. F. Holness, borough engineer, Municipal Offices, 5, Lind Street, Ryde, I.O.W.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"VORTEX."—Metal castings. Charles S. Madan & Company, Limited, Vortex Works, Atlantic Street, Broadheath, Altrincham.

"MAGNAL."—Machinery and machine tools for die-stamping and casting. Magnal Products, Limited, Tower Road, Warmley, Gloucestershire.

Aluminium and Antimony in Cast Red Brass

H. B. GARDNER and C. M. SAEGER, JR., in a Paper presented to the annual meeting of the American Foundrymen's Association, have experimented with additions of aluminium in amounts from 0.005 to 0.10 per cent. to red brass, made of remelted metal, of the nominal composition of 85 per cent. copper and 5 per cent. each of tin, zinc, and lead. Determinations of tensile properties, density, hardness, the running property, and the ability to withstand hydraulic pressure, made on various types of test-bars and test specimens, showed that all additions of aluminium had a deleterious effect on the properties and the structure. The effect was more pronounced with the higher concentrations of aluminium and was particularly evident on the ductility and the resistance to hydraulic pressure. Additions of antimony to this alloy in the amounts ranging from 0.10 to 0.25 per cent. had only a nominal effect on all of the properties studied, except the running property which was increased. These results indicated that the presence of 0.25 per cent. antimony is permissible, but that even 0.005 per cent. aluminium has a deleterious effect on the alloy.

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Raw Material Markets

It has been announced that prices of the products covered by the associations of basic pig-iron producers; Scottish, Midland, Welsh and North-East Coast steelmakers; British joist-makers; soft basic billet; basic special steel billet; free-cutting steel billet; forging, drop forging and stamping blooms, slabs and billets; and British sheet-bar makers, will be maintained at their present level during the third quarter of the year, subject to the provision in all sales and contracts that deliveries after October 31 will be at Association prices then ruling. The price of all qualities of hematite will be reduced by 5s. per ton on July 1.

There has been a small expansion in the demand for foundry iron of late, but trade is still very quiet, and consumers will not generally entertain the idea of booking ahead. The steel market, on the other hand, is increasing in strength, and outputs are well accounted for over quite a long period.

Pig-Iron

MIDDLESBROUGH.—Local foundrymen appear to be slightly better employed than they were, largely as a result of the more active conditions in the shipbuilding industry, but order-books are still far from being satisfactorily filled. At the present time only one blast furnace is making Cleveland foundry iron, and the output of this furnace is more than sufficient to meet all orders. There is little or no call for supplies from Scotland, owing to the quiet conditions existing there. A moderate amount of forward buying has been done in hematite, but, on the whole, business is still confined to deliveries under existing contracts. Consumption is certainly better than it was a few months ago, but stocks have still to be worked off.

LANCASHIRE.—Business among consumers of foundry iron is a little improved, and some of the trades which have been badly situated for work are now better placed. There has been a noticeable increase in the number of orders placed with jobbing founders and light-castings makers, although both these sections would welcome further expansion of trade. Machine-tool makers and heavy electrical engineers generally are active. Forward ordering of foundry iron is not being entered into in most instances, but some producers have booked supplies as far ahead as the end of the year. Hematite iron is being taken up rather more freely.

MIDLANDS.—The light-castings trade has not shown any marked improvement during the past week, and business in this section of the market remains disappointing. On the whole, there has recently been rather more buying of high-phosphorus iron, as it is not anticipated that prices will be altered for some time to come, but the demand is still at a comparatively low ebb and commitments do not yet extend very far forward. Current quotations of low-phosphorus iron are from £5 7s. 6d. to £6, and there has been some very heavy business in this material recently. Hematite, too, is being taken up in substantial tonnages, but stocks are still quite large and it will be some time before new business becomes necessary on a large scale. Prices will be reduced at the end of next month.

SCOTLAND.—There has not been much change in the condition of the foundry iron market, and orders for this material continue to be unsatisfactory. There has recently been a better flow of business, but this does not indicate greater activity among consumers so much as their desire to accumulate stocks in case of an outbreak of European hostilities. Half-time among light-castings makers is common, and there does not appear to be any likelihood of an early improvement in these conditions. The current price of No. 1 foundry iron is 108s., and 105s. 6d. for No. 3, both f.o.t. furnaces. Although the local steelworks are very active, they are not in the market for large tonnages of iron, as they covered their requirements some time ago.

Coke

The trend of future prices of foundry coke is a matter for considerable conjecture. Makers will examine the situation at the end of June. The domestic demand at present is rather quiet, but blast-furnace coke is moving away well and the export market is quite active, so that it is difficult to prophesy what the producers' decision will be. For delivery to Birmingham and Black Country stations, the minimum price of both Durham and Welsh coke is 50s. 6d.

Steel

Ordinary commercial business in the steel market is being disturbed by the large amount of Government work now being done, and some users are having difficulty in arranging reasonably prompt delivery of their requirements. That civil orders must now take second place is all the more unfortunate, as until recently there was a pronounced shortage of business in the steel industry, and makers would have welcomed the business now being offered to them. All descriptions of joists and sections are well taken up. Structural engineers have particularly heavy needs, and, in the hope of securing early delivery, many of them are indicating on their orders that the material is wanted for immediate use and not for stocking purposes. Owing to the insistent demand for air-raid shelters, the sheet makers are fully employed on Government work; in fact, several producers have announced that their order-books are now closed for some time.

Scrap

With a further increase in the needs of the steel industry, supplies of scrap have become even more stringent. What supplies are at hand are being delivered as evenly as possible according to consumers' needs, but the demand is much in excess of the supply. Several steelworks are using more pig-iron in their furnace charges, but this involves consumers in added expense which they will not desire to meet for any length of time.

Metals

While consumption of non-ferrous metals generally appears to be well maintained, new business is still on the quiet side. Confidence in forward positions has by no means returned, but there has been a better tone as a result of the less tense international situation.

Copper.—On the whole, the copper statistics for last month were rather disappointing. The American Copper Institute reports that during April world stocks of refined metal increased by 17,000 short tons, to 523,000 tons; blister stocks fell by 6,000 tons. World consumption was 4,000 tons lower on the month, at 154,000 tons, which compared with an increase in the previous month of 8,000 tons. The production during April was made up of 160,000 tons of blister copper (164,000 tons in March) and 166,000 (171,000) tons of refined metal.

Fairly large supplies have changed hands during the past week in this country, but it must be appreciated that without the assistance of the armament makers the turnover would be at a low ebb. In the United States there has been a revival of buying since the price was lowered to 10 cents per lb., and on Wednesday of last week the turnover amounted to the large total of 32,288,000 lbs., as compared with only 2,710,000 lbs. on the previous day. It is not thought that the reduced quotation was entirely responsible for the increased activity, and it is suggested that it was largely due to a transfer of metal stocks from producers to their subsidiary fabricating companies.

Metal Exchange quotations were as follow:—

Cash.—Thursday, £42 to £42 1s. 3d.; Friday, £41 12s. 6d. to £41 13s. 9d.; Monday, £41 12s. 6d. to £41 13s. 9d.; Tuesday, £41 6s. 3d. to £41 7s. 6d.; Wednesday, £41 to £41 1s. 3d.

Three Months.—Thursday, £42 6s. 3d. to £42 7s. 6d.; Friday, £41 18s. 9d. to £42 1s. 3d.; Monday, £42 to £42 1s. 3d.; Tuesday, £41 13s. 9d. to £41 15s.; Wednesday, £41 6s. 3d. to £41 7s. 6d.

Tin.—Business has not involved very large tonnages of late, and quotations have been maintained, largely as a result of sentiment in the market. High premiums are being obtained for special descriptions of tin, owing to the shortage of prompt supplies. American buying is still rather dull, but it is believed that consumers there have still to take up additional supplies, as stocks are not heavy.

Official quotations were as follow:—

Cash.—Thursday, £226 to £226 5s.; Friday, £225 to £225 10s.; Monday, £225 5s. to £225 10s.; Tuesday, £225 15s. to £226; Wednesday, £225 5s. to £225 10s.

Three Months.—Thursday, £223 10s. to £223 15s.; Friday, £222 10s. to £222 15s.; Monday, £222 15s. to £223; Tuesday, £223 5s. to £223 10s.; Wednesday, £223 to £223 5s.

Spelter.—There are no fresh developments to report in connection with this metal. The tone of the market is firm, but with few exceptions consumers are not showing much interest in forward business. There has still been no announcement with regard to the application for a higher import duty on zinc.

Daily market prices:—

Ordinary. — Thursday, £13 15s.; Friday, £13 13s. 9d.; Monday, £13 11s. 3d.; Tuesday, £13 10s.; Wednesday, £13 8s. 9d.

Lead.—Consumption of this metal is at quite a satisfactory level, but trade has not recently been very active. There is quite a strong inquiry from the Continent, France particularly taking up heavy tonnages.

Day-to-day quotations:—

Soft Foreign (Prompt).—Thursday, £14 11s. 3d.; Friday, £14 10s.; Monday, £14 11s. 3d.; Tuesday, £14 10s.; Wednesday, £14 7s. 6d.

Scrap.—Business is generally confined to immediate requirements. Trade is quiet in most grades, but some forward orders are being placed for ingots.

Approximate selling prices for old metal:—New aluminium cuttings, £69; rolled, £57; cast, £30 to £35; foil, £80. Copper, £38 to £43; braziery, £35 to £36. Brass (clean), £20 to £24. Zinc, £10. Lead, £13 10s. Gunmetal, £38.

Pouring-Ladle Influence on Brass

MR. R. W. PARSONS, in a Paper presented to the American Foundrymen's Association in Cincinnati, has drawn the following conclusions from an extensive series of practical experiments:—

(1) Tests show that quality of red brass, as judged by appearance of fractures, is quite generally impaired during the first use of a new pouring ladle, even though the ladles seem to have been well dried and thoroughly preheated.

(2) The condition is that of gassed metal, showing fissures and the discoloured fracture which characterises silicon contamination, except that the bad casting surface is absent. Such metal may exude on solidification and may "burn in" to cores and moulds.

(3) The cause of the gassed metal is attributed to moisture—chemically combined in the lining material. The worst condition was experienced with ladles washed with a high-temperature cement containing an organic bond, but all lining materials altered the metal to some extent. The ladle is not the only source, metal may be gassed in the furnace or may become gassed in the mould, but, on the other hand, gassed metal exuded even when poured into dry-sand moulds.

(4) New clay-graphite crucibles caused the metal to boil violently and "flare" as if it were being badly gassed, but metal quality was actually benefited by such treatment.

(5) Giving the ladles a "heat up" with metal (about 3 min.) was effective in preventing any changes in metal quality during subsequent use.

(6) Contrary to generally accepted theory, when metal used for the "heat up" was poured back into the furnace, there was no measurable impairment of such metal when poured into castings (from a "used" ladle). When the metal boils appreciably, in all probability it would be better to pour the metal into pigs.

(7) The findings may serve to explain the gassing of metal which has been melted in a freshly patched furnace.

A.F.A. Gold Medallists

At the annual dinner of the American Foundrymen's Association, held last night in Cincinnati, three gold medals were presented. The J. H. Whiting gold medal was presented to Mr. James R. Allen (International Harvester Company) in recognition of his contribution to the foundry industry dealing with engineering aspects. The W. H. McFadden medal was awarded to Mr. Donald J. Campbell (President of Campbell Wyant & Cannon Foundry Company) in recognition of his company's outstanding accomplishments in the field of castings manufacture. The John A. Penton gold medal was awarded to Mr. Harold A. Falk (Falk Corporation) in recognition of his work in connection with apprenticeship training.